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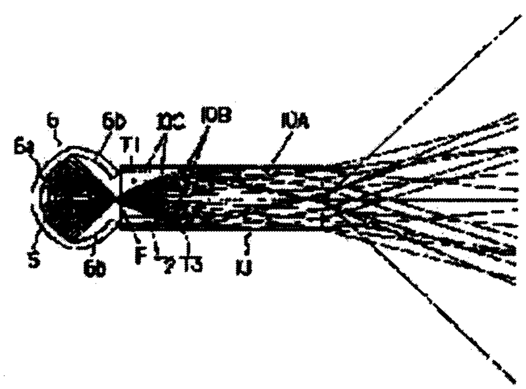
(54) ILLUMINATOR AND FLASH LIGHT EMITTING DEVICE FOR PHOTOGRAPHING

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain an efficient illumination optical system capable of controlling optional light condensing characteristic regardless of the outside shape of a light transmission member by forming the light incident part of the light transmission member of plural refractive index layers.



SOLUTION: Since luminous flux emitted from the center of a flash light emitting tube 5 arranged at the 1st focal position of an elliptical reflection surface 6a and advancing backward is condensed on the 2nd focal position F of an ellipse because the reflection surface 6a of a reflector 6 has elliptical shape. The incident surface of the light transmission member 10 is arranged in the vicinity of the focal position F. Then, the high refractive index layer 10A is arranged in the center part near the incident light part of the member 10 and the low refractive index layers 10B and 10C are arranged on the periphery thereof. The layers 10B and 10C are set to specified length in accordance with the characteristic of incident light. Thus, even in the case dispersion is found in the direction of the light beam when it is made incident, the irradiation of the luminous flux whose direction is arranged, that is, the irradiation corresponding to an optional necessary viewing angle range is executed after the light beam is emitted from the light transmission member.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the lighting system and the flash luminescence equipment for photography which control the injection light from the light source efficiently.
[0002]
[Description of the Prior Art] After carrying out multiple-times reflection of the flux of light injected from the light source for the purpose of acquiring the diffused light to the photographic subject of a short distance as shown in JP,4-16833,A as a lighting system which makes the light from the light source irradiate a photographic subject through the optical path which carries out multiple-times reflection conventionally with two or more plane mirrors arranged in the front face at abbreviation parallel and making it spread, the thing made to irradiate a photographic subject is proposed.
[0003] Moreover, as these people proposed by JP,59-165037,A, band-like is made to condense the flux of light injected from the flash arc tube, a fiber is arranged in the condensing section, and there are some which were constituted so that predetermined luminous intensity distribution might be obtained by bundling this suitably.
[0004]
[Problem(s) to be Solved by the Invention] However, in the conventional example of the above-mentioned former, since the plane mirror which has the spreading effect arranged to abbreviation parallel as a light guide line is used, it is easy to produce optical loss in the case of reflection in a mirror plane. For this reason, although it was convenient for it since extinction was made, although the photographic subject of a short distance is illuminated like close-up photography, the technical problem were unsuitable occurred to the purpose of making it condense efficiently.
[0005] Moreover, it constitutes from a conventional example of the above-mentioned latter so that the incidence section of a fiber may be arranged in the location which condensed the flux of light from a flash arc tube with the reflector and light may be led to the injection section of a fiber, but a fiber is a cylindrical shape-like, and since it cannot cover without a clearance, a quantity of light loss arises. Moreover, a fiber's being very expensive and a luminous-intensity-distribution property could be controlled within the fiber, and technical problems -- there is nothing (it is at the optical incidence and irradiation appearance time, and is the same condensing condition) -- occurred.
[0006] Even if this invention is an illumination system in the location which the optical incidence section and the optical injection section as a light-emitting part left, it aims at making condensing control of the light in the inside of a light guide line perform without being based on the appearance configuration of this light guide line.
[0007] Moreover, in the flash luminescence equipment used as lighting for photography, it aims at performing condensing control of the light from the light source efficiently at the same time it prevents the bloodshot-eyes phenomenon which poses a problem.
[0008] Furthermore, the optimal condensing optical system corresponding to the flash arc tube of the shape of a cylindrical shape used as the light source of the flash luminescence equipment for

photography is acquired. Namely, a beam of light is drawn through the thin light guide section corresponding to the light source, and it aims at irradiating the luminescence energy of the light source efficiently at a photographic subject.

[0009]

[Means for Solving the Problem] The lighting system concerning this invention has the condensing member which makes the flux of light from the light source condense, and the light guide section material which draws the flux of light condensed by this condensing member to a predetermined shot position, and the condensing control with the sufficient effectiveness which does not depend on the appearance configuration of the above-mentioned light guide section material is possible for this light guide section material in the optical incidence section by having two or more refractive-index layers which adjust the luminous-intensity-distribution property at the time of optical incidence.

[0010] Opening and the EQC of the flash arc tube with which the flash luminescence equipment for photography concerning this invention emits a flash, the reflector which makes the injection flux of light from this flash arc tube condense, and this reflector Or have optical plane of incidence larger than it, have the light guide section material which draws the flux of light to a predetermined shot position, and the above-mentioned light guide section material is set near the optical plane of incidence. Although it is necessary to detach a light-emitting part and the optical injection section in order to prevent a bloodshot-eyes phenomenon when using the flash luminescence equipment which is the light source of photography equipment by having two or more refractive-index layers which adjust the luminous-intensity-distribution property at the time of optical incidence By preparing refractive-index inclination in the light guide section material which connects during this period, it becomes possible to the luminous-intensity-distribution property at the time of optical incidence to amend suitably in the luminous-intensity-distribution property needed.

[0011] Moreover, the flash luminescence equipment for photography concerning this invention The flash arc tube which has an effective cylindrical shape-like light-emitting part, and the reflector which makes the injection flux of light from this flash arc tube condense, Opening of the abbreviation rectangle prepared in this reflector, and an EQC or optical plane of incidence larger than it, And it has the light guide section material which connects between this optical plane of incidence and an irradiation labor attendant and which consists of a reflector of thickness about 1 law. the irradiation labor attendant for making light irradiate in the direction of a photographic subject -- this light guide section material It becomes possible to be able to realize a compact light-emitting part gestalt with a thin shape, and to also set a condensing property as the optimal condition [near the optical incidence section] by having two or more refractive-index layers which adjust the luminous-intensity-distribution property at the time of optical incidence.

[0012]

[Embodiment of the Invention] Hereafter, one gestalt of implementation of this invention is explained.

[0013] Example of gestalt 1 drawing 1 of operation - drawing 4 are drawings showing the configuration at the time of applying this invention to the camera for photography, and the cross-sectional view in which in drawing 1 the perspective view of the whole camera and drawing 2 show the expansion perspective drawing of the important section of drawing 1 , and drawing 3 shows a photography condition, and drawing 4 are the cross-sectional views showing the condition of not taking a photograph.

[0014] In drawing 1 , 1 is lens-barrel barrier from which 3 protects the taking-lens lens-barrel section 2 as the body of a camera and 2 are shown in the taking-lens lens-barrel section and it is shown in drawing 4 at the time of carrying, as shown in drawing 3 at the time of photography, it rotates focusing on the hinge region 4 prepared in the upper part of a camera body, and evacuates up, and maintenance immobilization is carried out in a predetermined location.

[0015] Inside the body 1 of a camera, as shown in drawing 2 , the flash light-emitting part which consists of a reflector 6 as a condensing member which makes the flux of light from the flash arc tube 5 and this flash arc tube as the light source condense is arranged. Moreover, in the lens-barrel barrier 3, the light guide section material 7 which leads the injection flux of light from the flash light-emitting part

formed in the interior of the body 1 of a camera to a position is arranged.
[0016] In drawing 3 and the sectional view shown in 4, the sheathing member which 8 holds the light guide section material 7, and forms the lens-barrel barrier 3, and 9 are attachment components which hold the field of the opposite side in the sheathing member 8 of the light guide section material 7, and it is fixed to the sheathing member 8. In addition, the light guide section material 7 has prevented the optical loss by contact of a hand or other objects while it is held by the sheathing member 8, the attachment component 9, and predetermined spacing detached building ****** and prevents breakage by external force.
[0017] 10 is the closing motion member of the above-mentioned flash light-emitting part formed in the body 1 of a camera, as shown in drawing 3 in the state of photography, corresponding to a motion of the lens-barrel barrier 3, is driven by the device member within the body of a camera (un-illustrating), and shunts the front face of a flash light-emitting part. On the other hand, as shown in drawing 4 in the state of un-taking a photograph, it moves to the location which covers the front face of a flash light-emitting part, and invasion of dust, dust, etc. is prevented around a flash light-emitting part at the time of un-using [of the body 1 of a camera] it.
[0018] Moreover, drawing 3 also shows ray tracing of the representation flux of light injected from a flash arc tube. After carrying out incidence of the flux of light injected from the flash arc tube to the light guide section material 7 from the optical plane-of-incidence 7a like illustration and repeating total reflection, it is injected from irradiation labor attendant 7b. Like illustration, although the light guide section material 7 can be formed in the configuration corresponding to an appearance configuration, control of the luminous-intensity-distribution property in the condition that there is no thickness change is not easy the material. Hereafter, control of this luminous-intensity-distribution property is explained.
[0019] Drawing 5 and drawing 6 are drawings which explain the process in which condensing nature is changed, by refractive-index change in the light guide section material 7. Drawing 5 is the sectional view of the flash light-emitting part at the time of cutting perpendicularly to the cylinder-like flash arc tube 5, and drawing 6 is the sectional view of the flash light-emitting part at the time of using the ingredient of the single refractive index which does not have the refractive-index change section in light guide section material for a comparison.
[0020] In drawing 5 and drawing 6 , the reflector 6 which makes the luminescence flux of light from the flash arc tube 5 condense is formed by the ellipsoid to which the back section uses the core of the flash arc tube 5 as a focus to the direction of irradiation appearance, and the front section consists of cylinder sides centering on the flash arc tube 5 to the direction of irradiation appearance.
[0021] Although 10 is light guide section material, in order that it may give explanation easy, it is short, and is monotonous and consists of light guide section material 7 shown in said drawing 1 - drawing 4 . This light guide section material 10 is formed of the layers 10A-10C from which three sorts of refractive indexes differ, and a layer with the high refractive index to which 10A is extended from optical plane of incidence to an irradiation labor attendant, a layer with the low refractive index to which 10C is located in the outermost periphery of optical plane of incidence, and 10B are layers (a medium refractive index layer is called hereafter) which have the middle refractive index of both the above-mentioned layers 10A and 10C. As for the above-mentioned medium refractive index layer 10B and low layer 10C, only predetermined die length is constituted by the optical incidence section.
[0022] On the other hand, the light guide section material 11 shown in drawing 6 as a comparison is a single refractive-index layer, and the same ingredient as high refractive-index layer 10A of the light guide section material 10 is used for it so that the comparison with drawing 5 may become easy. In addition, the light guide section material 10 and 11 is constituted by glass or transparence resin, and adhesion immobilization of the interfaces T1 and T2 of each ********** of the light guide section material 10 is carried out by the transparence binder near the refractive index of class 10Aand10B, 10B, and 10C.
[0023] Next, the condition of ray tracing is explained about drawing 5 and drawing 6 . First, in drawing 5 , since reflector 6a of a reflector 6 is elliptical, the flux of light which injected from the core of the flash arc tube 5 arranged in the 1st focal location of ellipse reflector 6a, and progressed back condenses

in the 2nd focal location F of an ellipse (in order to simplify explanation, the effect of the refraction ignored as what has the glass thickness of the flash arc tube 5 thin enough). Since the plane of incidence of the light guide section material 10 is arranged near this 2nd focal location F, incidence of the reflected light which condensed in this focal location F is carried out to high refractive-index section 10A located in the center section of the light guide section material 10. First, it is refracted in plane of incidence, and about a component with the small include angle after incidence, high refractive-index section 10a is progressed as it is, and it injects from an irradiation labor attendant. Originally, this component is a component of a screen which can irradiate a center section mostly, is a component which is not carried out in the condensing control beyond this, and is injected at the same include angle as the time of incidence. Moreover, also by the component which hits the next medium refractive index layer 10B from high refractive-index layer 10A which carried out incidence of the component which carried out the incidence retroflexion chip box to the light guide section material 10 like illustration, when an incident angle is below a predetermined value, total reflection is carried out in the interface T1 of high refractive-index layer 10A and medium refractive index layer 10B, and it injects at the same include angle as the time of incidence. The classification of the control after being based on whenever [this incident angle] is determined by the ratio of the refractive index of the adjoining different refractive-index layer. That is, this refractive-index ratio opts for the first regulation of whenever [after incidence / illuminating-angle].

[0024] Although the example of illustration explained the component of high refractive-index layer 10A which carries out incidence from a center mostly The component (the same is said of the component generated with the component or direct light injected from the location from which it separated from the core of the flash arc tube 5, and it is an incidence component below a predetermined include angle) which separated from the center of high refractive-index layer 10A By the first above-mentioned regulation (interface T1 of high refractive-index layer 10A and medium refractive index layer 10B), it is injected of the same include-angle component as the time of incidence.

[0025] Next, at the time of incidence, about the component more than a predetermined include angle, about medium refractive index layer 10B and the large component of whenever [incident angle], light progresses to low refractive-index layer 10C further, and it becomes another control.

[0026] Hereafter, this ray tracing is explained.

[0027] In the case of the incident angle more than predetermined, total reflection is not carried out but it is refracted in the interface T1 of high refractive-index layer 10A and medium refractive index layer 10B. In order to carry out incidence of the refracted light to the refractive-index layers 10B and 10C lower than it from high refractive-index layer 10A at this time, the beam of light after refraction is changed into the component of the include angle near the direction of an optical axis. After carrying out total reflection of the beam of light after this refraction to injection or medium refractive index layer 10B from the end face of medium refractive index layer 10B as it is in the interface T2 of low refractive-index layer 10C, it is injected from the end face of medium refractive index layer 10B. According to this optical path of a series of, a beam of light is bent in the direction of an optical axis, and is changed into the component in a need field angle. The include-angle component controlled by adjusting suitably the ratio of the refractive index of medium refractive index layer 10B and low refractive-index layer 10C also in this case is limited.

[0028] Next, total reflection cannot be carried out to medium refractive index layer 10B on the boundary of low refractive-index layer 10C, i.e., by the initial state, about a component with the large incident angle to the light guide section material 10, incidence is further refracted and carried out from medium refractive index layer 10B to low refractive-index layer 10C, and remaining as it is or after carrying out total reflection by interface T3 with an air space, it injects from the end face of this low refractive-index layer 10C. Like the time of carrying out incidence from above-mentioned quantity refractive-index layer 10A to medium refractive index layer 10B also in this case, the flux of light after refraction is bent in the direction of an optical axis, and is changed into the component in a need field angle.

[0029] As mentioned above, by arranging high refractive-index layer 10A in the center section near the incident light section of the light guide section material 10, arranging the low refractive-index layers

10B and 10C on the outskirts, and setting the low refractive-index layers 10B and 10C as predetermined die length according to the property of incident light, as explained Even if vary and it is in the direction of the beam of light at the time of incidence, after light guide section material injection can perform the exposure corresponding to the flux of light to which the direction was equal, i.e., the need field angle range of arbitration.

[0030] In addition, it is the configuration which can prevent that the flux of light which carried out incidence to the low refractive-index layers 10B and 10C into once carries out re-incidence of the die length of the inside [this] low refractive-index layers 10B and 10C, and the thickness of a layer to a refractive-index layer higher than a current refractive-index layer again by total reflection. For this reason, an optimum value changes with the dispersion condition of the include angle of incident light, dispersion of an incidence location, etc.

[0031] Moreover, the exposure range after light guide section material injection is controlled by the ratio of each refractive-index layers 10A-10C, as mentioned above. Furthermore, the die length of the low refractive-index layers 10B and 10C is regulated by the value of high refractive-index layer 10A which carries out incidence first inside.

[0032] In the example 1 of a gestalt of above-mentioned operation, as a refractive-index layer, into quantity, although three sorts of low refractive-index layers 10A-10C are set up, by necessarily not being limited to these three layers and classifying a refractive index more finely, finer luminous-intensity-distribution control can be realized and it can consider as uniform lighting without nonuniformity.

[0033] Moreover, in order to verify the effectiveness of the above-mentioned example 1 of a gestalt, drawing 5 and drawing 6 are performing beam-of-light trace on the same conditions. First, as shown in drawing 6 , when the ingredient of a refractive index single as light guide section material 11 is used, the back before carrying out incidence to the light guide section material 11 is injected as the same component. (Among drawing, the two-dot chain line showed the greatest include-angle component at the time of incidence in respect of injection, and it was shown more clearly)

On the other hand, as shown in drawing 5 , it turns out to the maximum include angle at the time of incidence (two-dot chain line) that it is condensing as an assembly of the beam of light of a very narrow include angle in the case of the example 1 of a gestalt of the above-mentioned operation. Although the flux of light in the condition of the beam of light which came out of a part for the core of the flash arc tube 5 having reflected the representation beam of light in drawing in the back reflector, and having condensed to one point is shown The magnitude of the flash arc tube 5 is limited in fact, and it has the influence [in the field of the glass tube of the flash arc tube 5] of refraction, and it does not restrict only to this flux of light, but the light of various include-angle components not necessarily carries out incidence from the large field of high refractive-index section 10A. Also in this case, a large majority of flux of lights are normally regulated by control of the same beam of light as above-mentioned explanation. That is, the component with the large incident angle of the light guide section material 10 is changed into the include-angle component near the direction of an optical axis.

[0034] Hereafter, an actual numeric value is applied and the desirable example of a thing of the configuration of light guide section material based on the contents of the above-mentioned explanation is explained using drawing 7 .

[0035] In drawing 7 , 12 is light guide section material, and it is the high refractive index nH. It is medium refractive index nM to ingredient 12A. Ingredient 12B and low refractive index nL It consists of forms which stuck ingredient 12C on the both sides of the end face by the side of optical incidence.

[0036] First, each constant is defined as follows in configuration decision. Incidence of the flux of light which emitted light from the flash arc tube 5, and was condensed with the reflector 6 is carried out to the light guide section material 12 in a certain narrow fixed range. It is assumed that incidence of the frontage of this incidence section is carried out from the width of face a between Point P and Point Q. Width of face of b and low refractive-index layer 12C is set to c for the width of face of medium refractive index layer 12B, and it is the die length of d, inside, and the low refractive-index layers 12B and 12C about the width of face of the light guide section material 12 whole [0037]

[External Character 1]
l 又は (ℓ)

It carries out. Moreover, desired value of the maximum include angle of the flux of light after R, S, and light guide section material injection is set to alpha for the end face of medium refractive index layer 12B, and the intersection of the opposite side.
[0038] Fundamentally, among incident light, about the component of the include angle below alpha, an incident angle is controlled only within high refractive-index layer 12A, and injects from a injection side at the same include angle as whenever [incident angle]. At this time, it is the refractive index nM of this medium refractive index layer so that total reflection may be carried out even when medium refractive index layer 12B is hit, and it may not invade into medium refractive index layer 12B. It has set up.
[0039] Moreover, although an incident angle carries out incidence to medium-refractive-index 12B from high refractive-index layer 12A about the component of the include angle below beta more than alpha among incident light, on the boundary T2 of medium refractive index layer 12B and low refractive-index layer 12C, it is the component which carries out total reflection. Similarly, among incident light, more than beta, the component of the include angle below gamma is a component which can carry out incidence to medium refractive index layer 12B from high refractive-index layer 12A, and all low refractive-index layer 12C, and an incident angle is the component which carries out total reflection by interface T3 of low refractive-index layer 12C and air.
[0040] The inside of this [for making the flux of light controlled by the low refractive-index layers 12B and 12C inside invade into this layer altogether in addition to the above-mentioned conditions], The flux of light injected into the conditions of die-length l of a low refractive-index layer from the end face of the low refractive-index layers 12B and 12C To the conditions and pan it is made to be settled after light guide section material injection and within the predetermined include angle alpha, once, It is possible by fulfilling various conditions, such as conditions of the thickness of the low refractive-index layers 12B and 12C, to make it condense more efficiently inside inside for the flux of light which carried out incidence to the low refractive-index layers 12B and 12C not to return to the layer of a higher refractive index.
[0041] A monograph affair type is shown below.
[0042] - Relational expression in plane of incidence sin alpha=nH -sinthetaalpha (1-1)
sin beta=nH -sinthetabeta (1-2)
sin gamma=nH -sinthetagamma (1-3)
- Conditions no incidence component of the low refractive-index layers 12B and 12C to be a direct omission inside (the die length of l).
[0043]
[Equation 1]

$$\ell \geqq a \cdot \tan(90^\circ - \theta_\alpha) \qquad (2-1)$$

$$\therefore \quad \ell \geqq \frac{a}{\tan\theta_\alpha} \qquad (2-2)$$

- Conditional expression in a refractive-index change interface nH, sin(90 degree-thetabeta) =nM, and sinphibeta (3-1)
nH, sin(90 degree-thetagamma) =nM, and sinphigamma (3-2)
nM and sinphigamma=nL -sinpsigamma (3-3)
- Conditions for the maximum of injection light to carry out to below desired value, in case reentry light is carried out to high refractive-index layer 12A inside from the end face of the low refractive-index layers 12B and 12C (conditions made below into alpha as a last injection light).
[0044]
nM, sin(90 degree-phibeta) <=nH, and sinthetaalpha (4-1)

nL, sin(90 degree-psigamma) <=nH, and sinthetaalpha (4-2)
- The conditions for carrying out incidence to the low refractive-index layers 12B and 12C inside, and not carrying out reentry light to high refractive-index layer 12A after total reflection [0045]
[Equation 2]

$$b \cdot \tan\phi_{\beta} \geq \frac{\ell}{2} \qquad (5-1)$$

$$c \cdot \tan\phi_{\gamma} \geq \frac{\ell - b \cdot \tan\phi_{\gamma}}{2} \qquad (5-2)$$

- The conditions for preventing the component which is not controlled completely falling out from the end face of the low refractive-index layers 12B and 12C, and coming out of it inside, [0046]
[Equation 3]

$$a \cdot \tan(90^{\circ} - \theta_{\beta}) \leq \frac{\ell}{2} \qquad (6-1)$$

$$c \cdot \tan\phi_{\gamma} \leq \ell - \frac{a}{\tan\theta_{\gamma}} - b \cdot \tan\phi_{\gamma} \qquad (6-2)$$

Although it is desirable to fulfill all the above conditions, in order to enlarge thickly in fact, the actual example of count is shown in the form where some above-mentioned conditions are fulfilled.
(Example 1 of numerical calculation) They are the incident light aperture width a, the refractive index nH of high refractive-index section 12A, and the maximum illuminating angle alpha after injection, respectively a= 2.0 nH =1.60 It considers as alpha= 30 degrees and gives as initial value.
[0047] Moreover, as conditions, in order to make die-length l of the low refractive-index layers 12B and 12C into the shortest inside, it is [0048] from the aforementioned (2-2) formula.
[Equation 4]

$$\ell = \frac{a}{\tan\theta_{\alpha}} \qquad (7-1)$$

Moreover, in order to take as conditions the greatest large angle gamma which can be controlled (it is in agreement with maximum thetaalpha in injection from an end face), it is the above (4-1). nM, sin(90 degree-phibeta) =nH, and sinthetaalpha (8-1)
nL, sin(90 degree-psigamma) =nH, and sinthetaalpha (8-2)
Furthermore, as conditions, inside and after low refractive-index layer incidence are [0049] from a formula (5-1), in order not to carry out reentry light to a high refractive-index layer but to make it the thinnest.
[Equation 5]

$$b \cdot \tan\phi_{\beta} = \frac{\ell}{2} \qquad (9-1)$$

(5-2) From a formula, it is [0050].
[Equation 6]

$$c \cdot \tan\phi_{\gamma} = \frac{\ell - b \cdot \tan\phi_{\gamma}}{2} \qquad (9-2)$$

On the conditions alpha which carry out total reflection on a predetermined square by the above (3-1) of - (3-3), and conditional expression, i.e., an incident angle, on the boundary T1 of high refractive-index layer 12A and medium refractive index layer 12B Total reflection, The conditions which carry out total reflection by the angle of emergence beta on the boundary T2 of medium refractive index layer 12B and low refractive-index layer 12C are set to phibeta=0 and psigamma=0, and serve as a degree type. nM =nH and sin (90 degree-thetaalpha) (10-1)

nL =nH and sin (90 degree-thetabeta) (10-2)
From the above relation, it asks for each constant in following sequence. (1-1) It is [0051] from a formula and a formula (7-1).
[Equation 7]

$$\ell = \frac{a}{\tan\left[\sin^{-1}\left(\frac{\sin\alpha}{n_H}\right)\right]} \qquad (1\,1)$$

(10－1) 式と (1－1) 式より

$$n_M = n_H \cdot \cos\left[\sin^{-1}\ \frac{\sin\alpha}{n_H}\right] \qquad (1\,2)$$

(1－1) 式と (8－1) 式より

$$\phi_\beta = \cos^{-1}\ \frac{\sin\alpha}{n_M} \qquad (1\,3-1)$$

$$\beta = \sin^{-1}\left[n_H \cdot \sin\left(\cos^{-1}\left(\frac{n_M}{n_H}\cdot\sin\phi_\beta\right)\right)\right] \qquad (1\,3-2)$$

(9－1) 式より

$$b = \frac{\ell}{2\tan\phi_\beta} \qquad (1\,4)$$

(3－1) 式と (1－1) 式と (8－1) 式より

$$\theta_\beta = \cos^{-1}\left[\frac{n_M}{n_H}\cdot\sin\left(\cos^{-1}\left(\frac{\sin\alpha}{n_M}\right)\right)\right] \qquad (1\,5)$$

[0052]
[Equation 8]
(10－2) 式より

$$n_L = n_H \cdot \sin\,(90^\circ - \theta_\beta) \qquad (1\,6)$$

(8－2) 式と (1－1) 式より

$$\phi_\gamma = \cos^{-1}\left(\frac{\sin\alpha}{n_L}\right) \qquad (1\,7-1)$$

(3－3) 式と (1－3) 式より

$$\gamma = \sin^{-1}\left[n_H \cdot \sin\left(\cos^{-1}\left(\frac{n_L}{n_H}\cdot\sin\phi_\gamma\right)\right)\right] \qquad (1\,7-2)$$

(9－2) 式と (3－3) 式より

$$C = \frac{\ell - b\cdot\tan\left[\sin^{-1}\left(\frac{n_L}{n_H}\cdot\sin\phi_\gamma\right)\right]}{2\cdot\tan\phi_\gamma} \qquad (1\,8)$$

On the other hand, it is drawing 7 . d=a+2b+2c (19)
As mentioned above, a count result is alpha= 30.0 degrees. beta= 45.0 degrees gamma= 59.9 degrees a=2.0b=1.06 c= 0.75 d= 5.62 It is set to l=6.08nH =1.6000, nM =1.5199, and nL =1.4353. Drawing 7 is drawing which carried out based on this numeric value, and was drawn.
[0053] Moreover, if only the refractive index of high refractive-index section 12A is changed into nH =1.5 and same count is carried out, it will become the following examples 2 of numerical calculation. Namely, alpha= 30.0 degrees beta= 45.0 degrees gamma= 60.0 degrees a=2.0b=1.07 c= 0.76 d= 5.69 It is set to l=5.66nH =1.5000, nM =1.4142, and nL =1.3229, and becomes a value with it inside. [the die length of the low refractive-index layers 12B and 12C short 0.4mm, and] [almost same / others]
[0054] In the example of a gestalt of the above-mentioned numeric value, it became homogeneity luminous intensity distribution as the maximum include angle of 30 degrees after light guide section material injection, and each constant is set up so that there may be little loss. For this reason, although width of face is thick, distribution of the injection light of the light guide section material 12 is considered as distribution of central importance, and if loss light is permissible to some extent, it can constitute more thinly.
[0055] Moreover, the layer from which a refractive index differs is arranged in parallel to an optical axis like the above-mentioned explanation, and it is high in the refractive index of the incident light section, and by lowering a refractive index on the outskirts according to the other side, it classifies according to the include-angle component at the time of incidence, and it becomes possible to control the direction of a beam of light separately respectively. While being able to control light more finely and being able to narrow the include angle after final light guide section material injection by arranging many different refractive-index layers at this time, it becomes controllable to the component of a large include angle also about the include angle at the time of incidence.
[0056] Next, the example 3 of numerical calculation of the example 1 of a gestalt of the above-mentioned operation is explained. Although the conditions for making the die length of a low refractive-index layer into the shortest inside were given by the formula (7-1) in said example 1 of numerical calculation, the example 3 of numerical calculation explains the configuration which loses the component which escapes from and comes out of the end face of a low refractive-index layer in the condition of not being controlled completely, while being slightly generated in the example 1 of numerical calculation.
[0057] For fulfilling this condition and shortening the die length of the low refractive-index section inside, it is [0058] from (6-1) and a formula (6-2).
[Equation 9]

$$a \cdot \tan(90^\circ - \theta_\beta) = \frac{\ell}{2} \qquad (20-1)$$

$$c \cdot \tan\phi_\gamma = \ell - \frac{a}{\tan\theta_\gamma} - b \cdot \tan\phi_\gamma \qquad (20-2)$$

The conditions for taking the large include angle gamma of expansion which can be controlled in addition to this condition (8-1), (8-2) A predetermined value is calculated into a formula and after low refractive-index layer incidence from conditions [which are not in a high refractive-index layer reentry putting] (9-1), formula (9-2), conditions [which carry out total reflection at a predetermined include angle] (10-1), formula (10-2), and definition type [in each refracting interface] (1-1) - (1-3) - (3-1) (3-3) a formula.
[0059] They are the incident light aperture width a, the refractive index nH of high refractive-index section 13A, and the illuminating angle alpha after injection, respectively a= 2.0 nH =1.60 It is [0060] when low refractive-index layer 13B is made into one layer, as the same value as the example 1 of numerical calculation is given as alpha= 30 degrees and it is shown in drawing 8 .
[Equation 10]

（1－1）式と（10－1）式より

$$n_L = n_H \cdot \sin\left(90^\circ - \sin^{-1}\frac{\sin\alpha}{n_H}\right) = 1.5199$$

（8－1），（1－1）式より

$$\phi_\beta = \cos^{-1}\frac{\sin\alpha}{n_L} = 70.7934$$

（3－1）式より

$$\phi_\beta = \cos^{-1}\frac{n_L}{n_H}\sin\phi_\beta = 26.2254$$

（20－1）式より

$$\ell = 2a \cdot \tan(90^\circ - \theta_\beta) = 8.12$$

（9－1）式より

$$b = \frac{\ell}{2 \cdot \tan\phi_\beta} = 1.4144$$

(1-2) If the result beyond beta=sin-1(nH and sinthetabeta) =44.9951d=a+2b=4.8288 is summarized from a formula alpha= 30.0 degrees beta= 45.0 degrees a= 2.0 b=1.41d=4.83, l= 8.12 It is set to nH =1.6000 and nM =1.5199, and a 60-degree illuminating angle narrows the component of the 90-degree illuminating angle in the predetermined range a by the above-mentioned configuration.
[0061] The same effectiveness is acquired, even when sufficient thickness cannot necessarily be taken even if by constituting so that a refractive index may be lowered, without being limited to this configuration as the layer from which a refractive index differs is formed so that it may become abbreviation parallel to the direction of an optical axis, and the incidence section is separated from the high refractive-index section and an optical axis although each above-mentioned configuration showed the configuration which prevents a quantity of light loss as much as possible.
[0062] By refractive-index change in light guide section material, example of gestalt 2 drawing 9 of operation - drawing 12 are drawings explaining the example 2 of a gestalt of the operation of a process to which condensing nature is changed, and since the whole configuration etc. is the same as that of the example 1 of a gestalt of operation, they explain only a characteristic part.
[0063] In drawing 9 , 14 is light guide section material, consists of four layers 14A, 14B, 14C, and 14D from which a refractive index differs, and has become plate-like as an appearance configuration. A high refractive-index layer, and 14B and 14D of 14A and 14C are low refractive-index layers here. As for the example 2 of a gestalt of this operation, it is the description in the example 1 of a gestalt of operation that it differs, a different refractive-index ingredient is installed in the direction of an optical axis, and the plane of composition is a curved surface. Thus, by constituting, effectiveness which has arranged two or more convex lenses to the incident-ray side is acquired.
[0064] Hereafter, ray tracing at the time of using the light guide section material 14 of such a configuration is explained about drawing 10 - drawing 12 . In order to simplify explanation, the beam of light injected from the center of the flash arc tube 5 is shown.
[0065] First, behind an optical axis, as shown in drawing 10 , the other flux of light condenses in the 2nd focal location F of an ellipse among the flux of lights injected from the flash arc tube 5 arranged in the 1st focal location of the ellipse reflector 6, after hitting ellipsoid 6a of a reflector 6 (in order to simplify explanation, the effect of the glass tube of a flash arc tube is disregarded). Since high refractive-index section 14A of the condensing member 14 is arranged near this 2nd focal location F, incidence of the reflected light which ****(ed) in the 2nd focal location F is carried out to high refractive-index section

14A, and it is refracted. Next, incidence is carried out to the interface T1 of high refractive-index section 14A and low refractive-index section 14B. Since this interface consists of curved surfaces, an incident angle cannot be small influenced easily of refraction.
[0066] Furthermore, from low refractive-index layer 14B, it progresses to high refractive-index layer 14C, and is refracted. Incidence of the last is carried out to low refractive-index layer 14D from high refractive-index layer 14C. Since an interface T2 consists of curved surfaces, also at this time, an incident angle is small, and it can suppress the deflection of the include angle by refraction.
[0067] As mentioned above, condensing effectiveness can be given by arranging high refractive-index layer 14A and low refractive-index layer 14B in order near the plane of incidence of the light guide section material 14, and constituting high refractive-index layer 14A so that it may become a concave lens configuration about convex lens configuration and low refractive-index layer 14B.
[0068] Drawing 11 shows the condition in case the flux of light injected from the center of the flash arc tube 5 carries out incidence to the light guide section material 14 directly. Like illustration, the high refractive-index layers 14A and 14C have the effectiveness of a convex lens, and a property which condenses from the light guide section material 14 to one point after injection can be acquired.
[0069] Drawing 12 illustrates the component to which the flux of light which came out of the flash arc tube 5 hits cylinder-like reflector 6b. This flux of light condenses in the 2nd focal location F after reflection by ellipse reflector 6a toward back after reflection through the core of the flash arc tube 5 again by cylinder-like reflector 6b. The following takes the same optical path as drawing 10 .
[0070] As mentioned above, as explained, the high refractive-index sections 14A and 14C can change a condensing property, keeping an appearance configuration constant, when a center makes the circumference thin thickly and the low refractive-index sections 14B and 14D make the laminating of the layer with the thick circumference with a thin center carry out in the direction of an optical axis near the plane of incidence of light guide section material.
[0071] Although quantity and every two layers each of **** refractive-index layers were carried out a total of four stratification in the example 2 of a gestalt of this operation, it is also possible to increase the number of these layers, and constituting only from two-layer is also possible. All can carry out adjustable [of the condensing degree] with the difference of a quantity and low refractive index, and the magnitude of curvature.
[0072] Moreover, in the example 2 of a gestalt of this operation, without not necessarily being limited to this configuration, although one side is made into the flat surface, all mirror interfaces can also be formed on a convex or a concave surface, and this gentleman can condense efficiently. Moreover, the larger one can also make a refractive-index difference condense efficiently.
[0073] Example of gestalt 3 drawing 13 of operation - drawing 15 are drawings for explaining the example 3 of a gestalt of operation of this invention. The whole configuration etc. is the same as that of the example 1 of a gestalt of operation, and adds explanation only about a characteristic part.
[0074] In drawing 13 , 15 is light guide section material and, as for the high refractive-index section and 15B, the cross-section configuration of 15A is the low refractive-index section made into three square shapes. The description of this operation is a configuration with the middle property of the examples 1 and 2 of a gestalt of operation, and explains the property of a configuration based on drawing 14 and the ray-tracing Fig. shown in 15. The component reflected with the back reflector among the flux of lights which came out from the core of the flash arc tube 5 as first shown in drawing 14 condenses to another focus F of an ellipse, and carries out incidence to the light guide section material 15. As the example 2 of a gestalt of operation explained the component which is injected to high refractive-index section 15A with incidence Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne. and which went on the outskirts on the other hand like the example 1 of a gestalt of operation, the part of three square shapes of low refractive-index section 15B has the effectiveness equivalent to a concave lens, only a component especially with a large incident angle is controlled by the part here, and the flux of light near the optical axis condenses.
[0075] Although drawing 15 is the direct light from the flash arc tube 5, it turns out that it is effectively condensed in the part of three square shapes formed by the above-mentioned low refractive-index

section 15B also in this case, and is injected from the end face of light guide section material.
[0076] Example of gestalt 4 drawing 16 of operation is drawing for explaining the example 4 of a gestalt of operation of this invention. Since the whole configuration etc. is the same as that of the example 1 of a gestalt of operation, it explains only a characteristic part.
[0077] In drawing 16 , 16 is light guide section material, and 16A is the optical material of a refractive-index distribution pattern, and is the quality of the material with which it has a refractive index with the high refractive index of a core, and a low periphery, and change of a refractive index gave change to parabolic. The die length is regulated by predetermined die length so that it may mention later. 16B is a light guide section which consists of a single refractive index connected to the optical-axis end face of refractive-index part cloth layer 16A, and this die length can be made the die length of arbitration according to the die length of the optical system to be used.
[0078] This drawing also shows the ideal beam-of-light trace at the time of using this optical system to coincidence.
[0079] The other component condenses in another focal location of an ellipse back among the flux of lights injected from the center of the flash arc tube 5. The flux of light which carried out incidence near the optical-axis core of the light guide section material of the light guide section material 16 which has arranged plane of incidence near [this] the condensing can be made abbreviation parallel by setting the die length of this layer as predetermined die length in refractive-index part cloth layer 16A. The flux of light is drawn to a predetermined location, carrying out incidence to single refractive-index layer 16B, and holding this beam-of-light condition, after being made parallel.
[0080] Especially when the plane of incidence of light guide section material is large, this method is effective to the light source, so that the flux of light from the light source may become equivalent to the condition fully condensed on the optical axis by the reflector etc., or it.
[0081] Moreover, the thing of the die length used at the time of the image formation relation of the lens of the refractive-index distribution pattern usually used by the cel hook (trade name) lens, the rod lens, etc. exactly been half characterizes the die length of refractive-index part cloth layer 16A.
[0082] Moreover, about this length, it is desirable to make it the optimal die length according to the property of the beam of light which carries out incidence to light guide section material, without being limited to the above-mentioned die length.
[0083]
[Effect of the Invention] Since the optical incidence section of light guide section material was formed in two or more refractive-index layers according to this invention as explained above, it is not based on the appearance configuration of light guide section material, but becomes controllable [the condensing property of arbitration], and is effective in an efficient illumination-light study system being realizable.
[0084] Moreover, since it is possible to make the die length of light guide section material into the die length of arbitration, it is possible to separate the optical injection section from a photography optical axis, and the bloodshot-eyes phenomenon which poses a problem at the time of photography using flash luminescence equipment can be prevented beforehand.
[0085] Furthermore, [near the optical incidence section], since light guide section material forms two or more refractive-index layers, a compact light-emitting part gestalt can be realized with a thin shape, and it can also set a condensing property as an optimum state. And the configuration of optical system is also comparatively easy and there is effectiveness of being able to constitute cheaply.

[Translation done.]

* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] It is the lighting system which has the condensing member which makes the flux of light from the light source condense, and the light guide section material which draws the flux of light condensed by this condensing member to a predetermined shot position, and is characterized by equipping the above-mentioned light guide section material with two or more refractive-index layers which adjust the luminous-intensity-distribution property at the time of optical incidence [near the optical plane of incidence].
[Claim 2] Light guide section material according to claim 1 is a lighting system characterized by having arranged the high refractive-index section to the core, and arranging the low refractive-index section in the periphery section.
[Claim 3] Light guide section material according to claim 1 is a lighting system characterized by having the refractive-index layer from which plurality differs near the optical plane of incidence at least, and having the layer which has uniform refractive-index distribution in the part near an irradiation labor attendant.
[Claim 4] A condensing member according to claim 1 is a lighting system characterized by being formed by the paraboloid to which the back section uses the core of the light source as a focus to the direction of irradiation appearance, and the front section consisting of cylinder sides centering on the light source to the direction of irradiation appearance.
[Claim 5] Opening of a condensing member according to claim 1 is a lighting system characterized by countering a high refractive-index part among the optical plane of incidence of the above-mentioned light guide section material, and being arranged.
[Claim 6] Light guide section material according to claim 1 is a lighting system characterized by having arranged the low refractive-index layer at an optical axis and parallel at a periphery to a central high refractive-index layer.
[Claim 7] Light guide section material according to claim 1 is a lighting system characterized by forming continuously a configuration equivalent to a lens or it which serves as power forward in the high refractive-index section, and power negative in the low refractive-index section on the optical axis [near the optical plane of incidence].
[Claim 8] Light guide section material according to claim 1 is a lighting system characterized by being constituted with glass or transparence resin.
[Claim 9] Light guide section material according to claim 1 is a lighting system characterized by preparing in a periphery the low refractive-index layer which narrows a high refractive-index layer gradually [near the optical plane of incidence].
[Claim 10] It is the lighting system with which light guide section material according to claim 1 consists of an optical material of a refractive-index distribution pattern [near the optical plane of incidence], and the die length of the layer of this refractive-index distribution pattern is characterized by the thing of the die length of an image formation system for which it has the half die length mostly.
[Claim 11] The interface of each ********** of light guide section material given in either of claims 2,

3, 6, 7, 9, and 10 is a lighting system characterized by carrying out adhesion immobilization by the transparence binder near the refractive index of each class.
[Claim 12] Light guide section material according to claim 1 is a lighting system characterized by having installed the different refractive-index layer in the direction of an optical axis, and constituting at least one side of each class from a curved surface.
[Claim 13] It is flash luminescence equipment for photography which has opening of the flash arc tube which emits a flash, the reflector which makes the injection flux of light from this flash arc tube condense, and this reflector, an EQC, or optical plane of incidence larger than it, consists of light guide section material which draws the flux of light to a predetermined shot position, and is characterized by forming [at least / near the optical plane of incidence] the above-mentioned light guide section material from two or more refractive-index layers.
[Claim 14] The flash arc tube which has an effective cylindrical shape-like light-emitting part, and the reflector which makes the injection flux of light from this flash arc tube condense, It consists of light guide section material which connects optical outgoing radiation face-to-face to the irradiation labor attendant for making opening, an EQC, or the optical plane of incidence and light of the abbreviation rectangle prepared in this reflector larger than it irradiate in the direction of a photographic subject, and this optical plane of incidence and which consists of a smooth side of thickness about 1 law. The above-mentioned light guide section material is flash luminescence equipment for photography characterized by being formed from two or more refractive-index layers [near the optical plane of incidence] at least.
[Claim 15] Light guide section material according to claim 13 or 14 is flash luminescence equipment for photography characterized by having arranged the high refractive-index section to the core, and arranging a low refractive index in the periphery section.
[Claim 16] Light guide section material according to claim 13 or 14 is flash luminescence equipment for photography characterized by having the refractive-index layer from which plurality differs near the optical plane of incidence at least, and having the layer which has uniform refractive-index distribution in the part near a injection side.
[Claim 17] A condensing member according to claim 13 or 14 is flash luminescence equipment for photography characterized by being formed by the paraboloid to which the back section uses the core of the light source as a focus to the direction of irradiation appearance, and the front section consisting of cylinder sides centering on the light source to the direction of irradiation appearance.
[Claim 18] Opening of a reflector according to claim 13 or 14 is flash luminescence equipment for photography characterized by countering a high refractive-index part among the optical plane of incidence of the above-mentioned light guide section material, and being arranged.
[Claim 19] Light guide section material according to claim 13 or 14 is flash luminescence equipment for photography characterized by having arranged the low refractive-index layer at an optical axis and parallel at a periphery to a central high refractive-index layer.
[Claim 20] Light guide section material according to claim 13 or 14 is flash luminescence equipment for photography characterized by forming continuously a configuration equivalent to a lens or it which serves as power forward in the high refractive-index section, and power negative in the low refractive-index section on the optical axis [near the optical plane of incidence].
[Claim 21] Light guide section material according to claim 13 or 14 is flash luminescence equipment for photography characterized by being constituted with glass or transparence resin.
[Claim 22] Light guide section material according to claim 13 or 14 is flash luminescence equipment for photography characterized by preparing in a periphery the low refractive-index layer which narrows a high refractive-index layer gradually [near the optical plane of incidence].
[Claim 23] It is flash luminescence equipment for photography with which light guide section material according to claim 13 or 14 consists of an optical material of a refractive-index distribution pattern [near the optical plane of incidence], and the die length of the layer of this refractive-index distribution pattern is characterized by the thing of the die length of an image formation system for which it has the half die length mostly.
[Claim 24] The interface of each ********** of light guide section material given in either of claims 2,

3, 6, 7, 9, and 10 is flash luminescence equipment for photography characterized by carrying out adhesion immobilization by the transparence binder near the refractive index of each class.
[Claim 25] Light guide section material according to claim 13 or 14 is flash luminescence equipment for photography characterized by having installed the different refractive-index layer in the direction of an optical axis, and constituting at least one side of each class from a parish side.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The perspective view of the whole camera concerning the example 1 of a gestalt of operation of this invention.
[Drawing 2] The perspective view having seen through and shown only the optical system concerning the example 1 of a gestalt of operation of this invention.
[Drawing 3] The sectional view of the camera busy condition concerning the example 1 of a gestalt of operation of this invention.
[Drawing 4] The sectional view at the time of camera carrying concerning the example 1 of a gestalt of operation of this invention.
[Drawing 5] The sectional view for explaining the illumination-light study system concerning the example 1 of a gestalt of operation of this invention.
[Drawing 6] The sectional view of the comparison for explaining the illumination-light study system concerning the example 1 of a gestalt of operation of this invention.
[Drawing 7] The sectional view for explaining the property of the light guide section material concerning the example 1 of a gestalt of operation of this invention.
[Drawing 8] Other sectional views for explaining the property of the light guide section material concerning the example 1 of a gestalt of operation of this invention.
[Drawing 9] The sectional view for explaining the illumination-light study system concerning the example 2 of a gestalt of operation of this invention.
[Drawing 10] Rear-face reflected ray traced drawing of the illumination-light study system concerning the example 2 of a gestalt of operation of this invention.
[Drawing 11] Direct beam-of-light traced drawing of the illumination-light study system concerning the example 2 of a gestalt of operation of this invention.
[Drawing 12] Front reflected ray traced drawing of the illumination-light study system concerning the example 2 of a gestalt of operation of this invention.
[Drawing 13] The sectional view for explaining the illumination-light study system concerning the example 3 of a gestalt of operation of this invention.
[Drawing 14] Rear-face reflected ray traced drawing of the illumination-light study system concerning the example 3 of a gestalt of operation of this invention.
[Drawing 15] Implantation beam-of-light traced drawing of the illumination-light study system concerning the example 3 of a gestalt of operation of this invention.
[Drawing 16] The sectional view for explaining the illumination-light study system concerning the example 4 of a gestalt of operation of this invention.
[Description of Notations]
5 Flash Arc Tube (Light Source)
6 Reflector (Condensing Member)
7, 10, 11, 12, 13, 14, 15, 16 Light guide section material
7a Optical plane of incidence

7b Irradiation labor attendant
8 Sheathing Member
9 Protection Member
10A, 12A, 14A, 14C, 15A Quantity refractive-index layer
10B, 12B Medium refractive index layer
10C, 12C, 14B, 14D, 15B Low refractive-index layer

[Translation done.]

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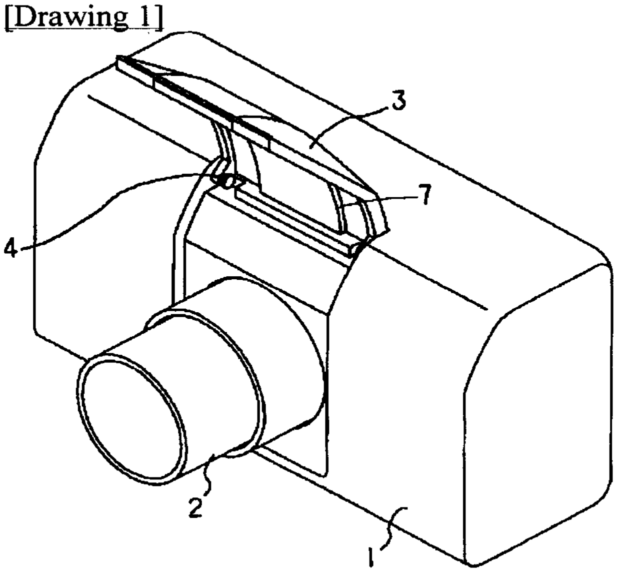
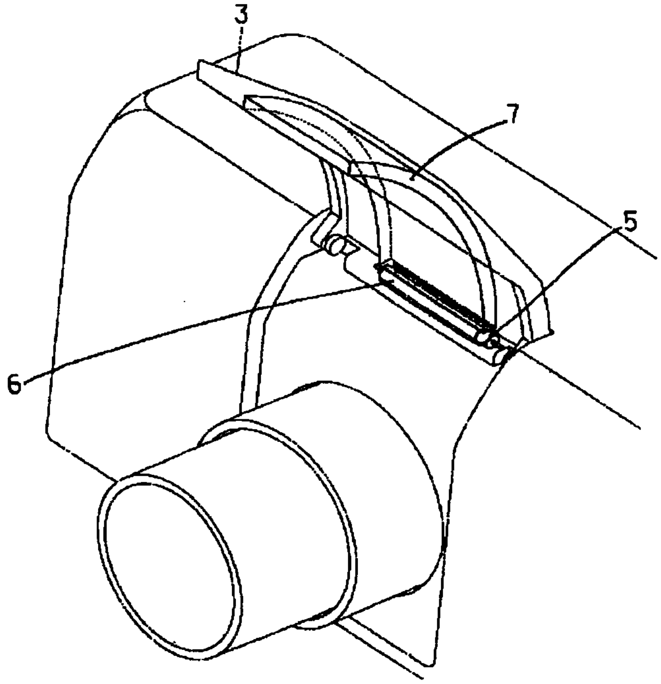
DRAWINGS

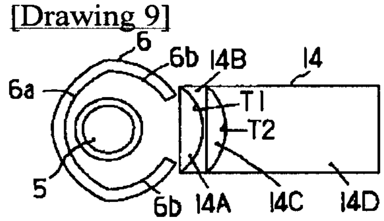
[Drawing 1]



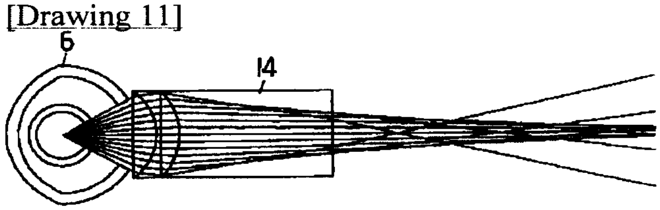
[Drawing 2]



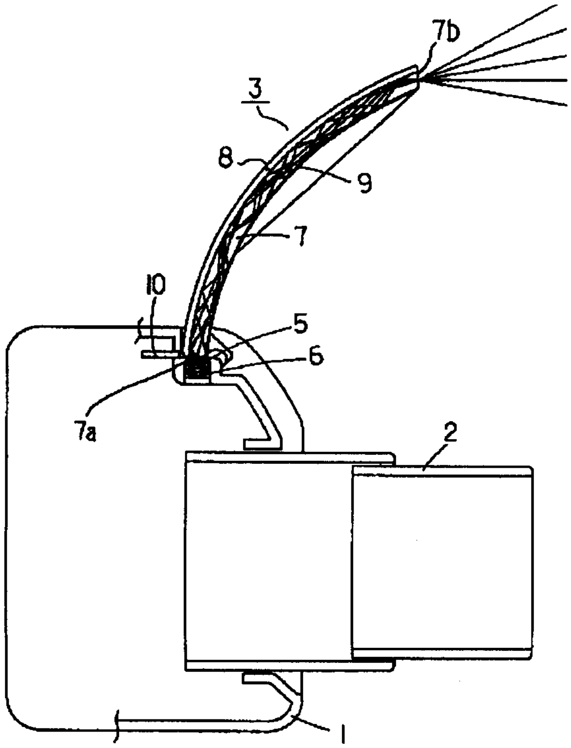
[Drawing 9]



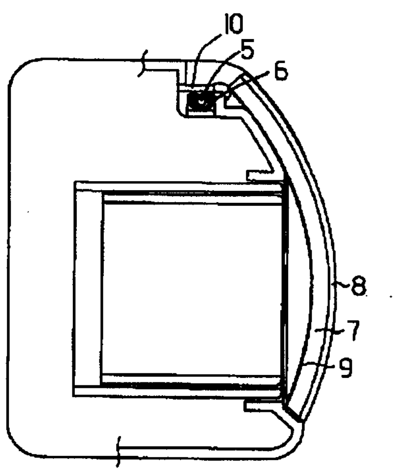
[Drawing 11]



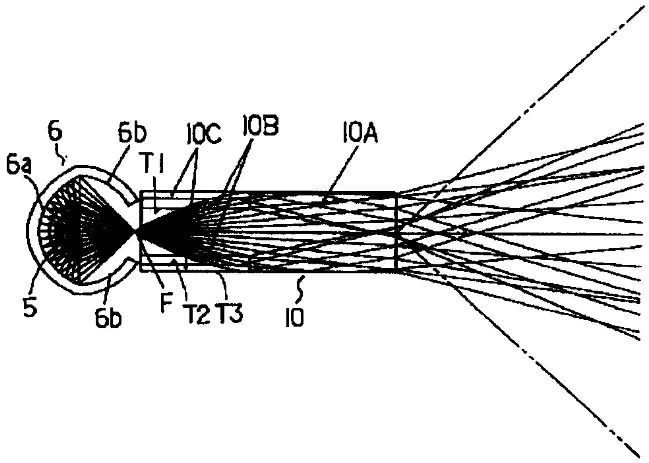
[Drawing 3]



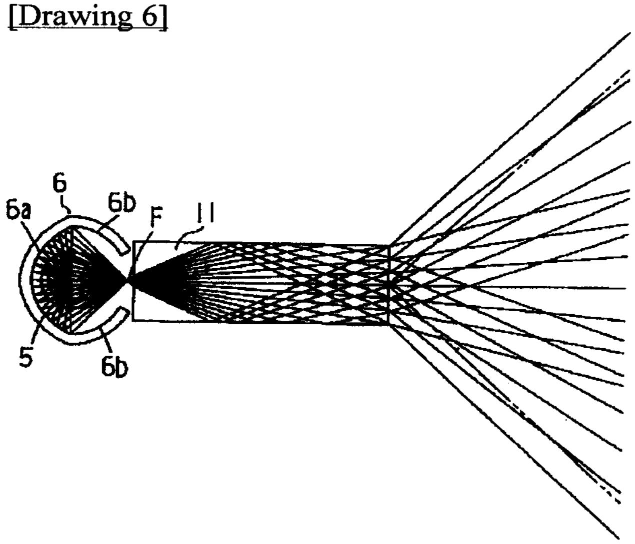
[Drawing 4]



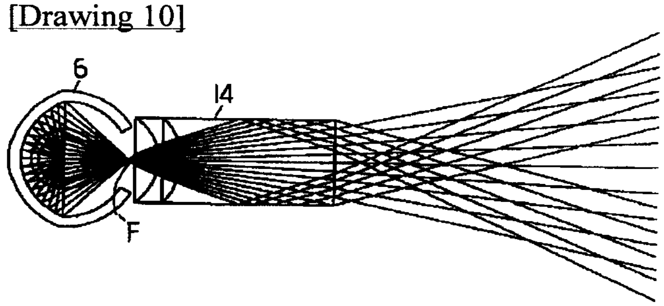
[Drawing 5]



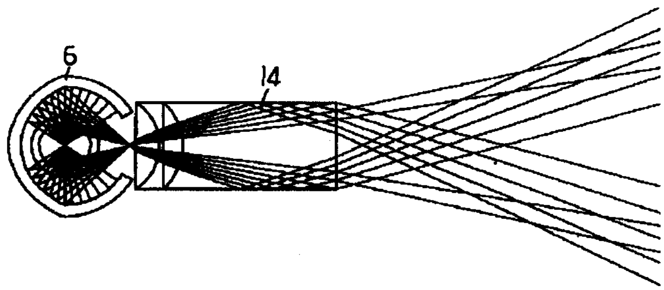
[Drawing 6]



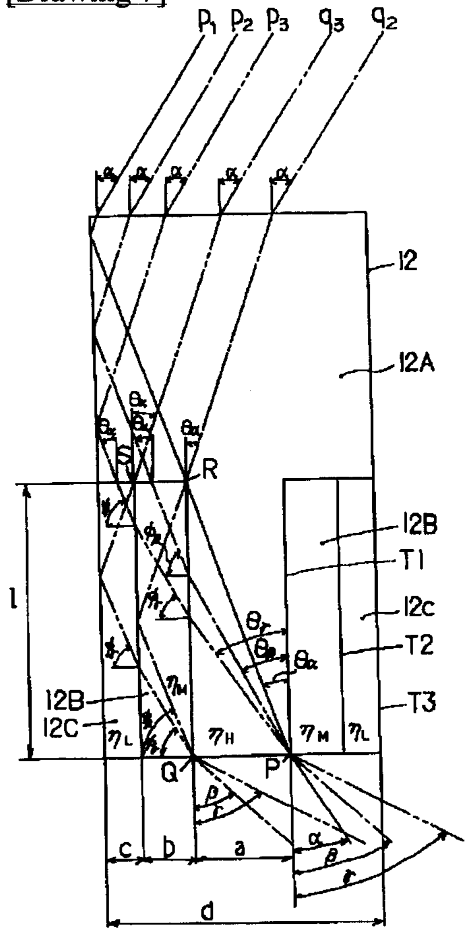
[Drawing 10]



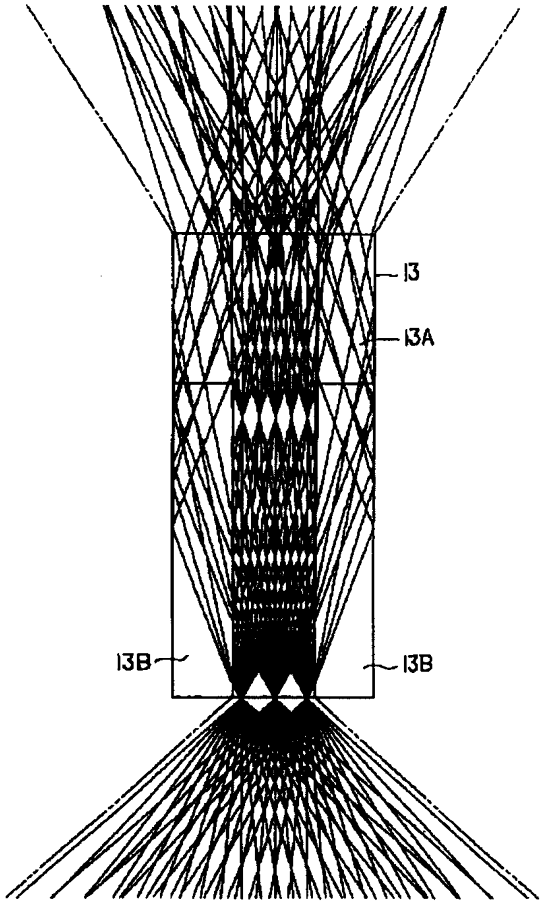
[Drawing 12]



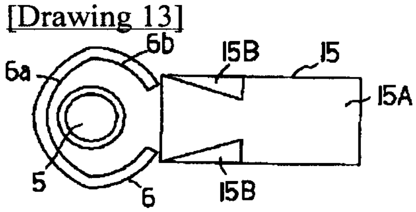
[Drawing 7]



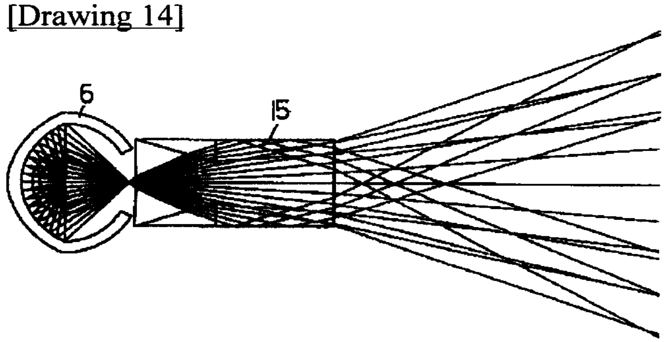
[Drawing 8]



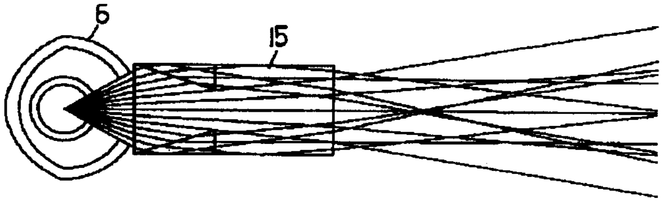
[Drawing 13]



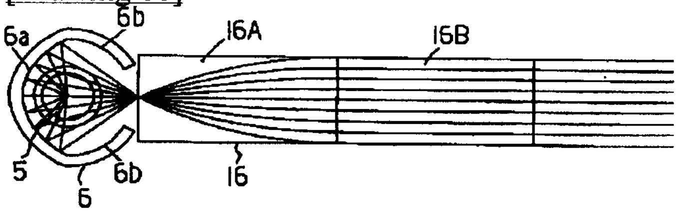
[Drawing 14]



[Drawing 15]



[Drawing 16]



[Translation done.]

* NOTICES *

CORRECTION OR AMENDMENT

[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
[Section partition] The 2nd partition of the 6th section
[Publication date] February 9, Heisei 13 (2001. 2.9)

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F21V 8/00

G03B 15/05

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F21V 8/00 B
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[Filing Date] May 18, Heisei 12 (2000. 5.18)
[Procedure amendment 1]
[Document to be Amended] DRAWINGS
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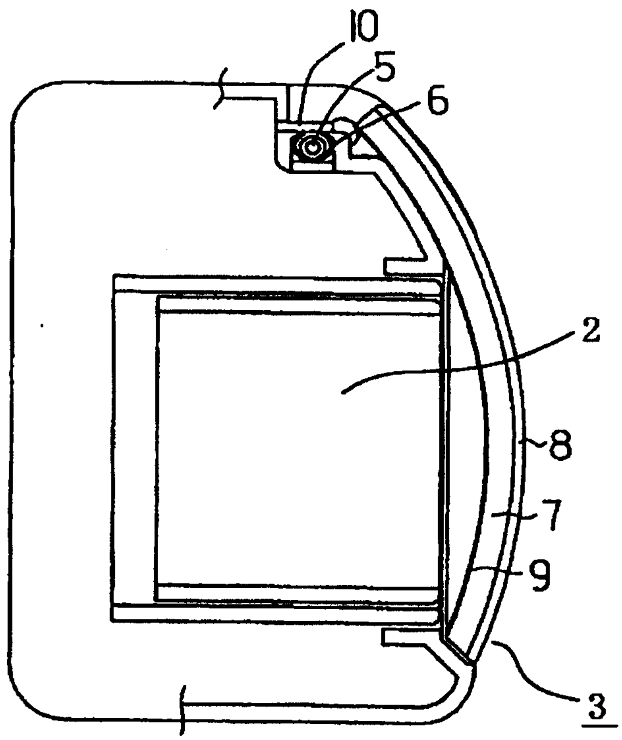

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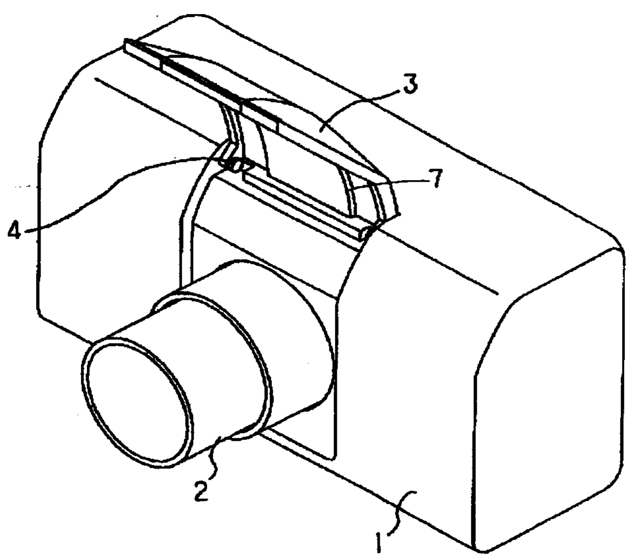
(54)【発明の名称】　照明装置および撮影用閃光発光装置

(57)【要約】

【課題】　光源からの光束を該光源から離れた位置に導光するには光損失が生じ、その位置に効率良く制御することが困難であった。

【解決手段】　光源５からの光束を集光させる集光部材６と、該集光部材によって集光された光束を所定の射出位置まで導く導光部材７とから成り、上記導光部材７は、少なくとも光入射部近傍において、複数の屈折率層で構成している。



【特許請求の範囲】

【請求項１】　光源からの光束を集光させる集光部材と、該集光部材によって集光された光束を所定の射出位置まで導く導光部材を有し、上記導光部材は、光入射面近傍において、光入射時の配光特性を調整する複数の屈折率層を備えることを特徴とする照明装置。

【請求項２】　請求項１記載の導光部材は、中心部に高屈折率部、外周部に低屈折率部を配列したことを特徴とする照明装置。

【請求項３】　請求項１記載の導光部材は、少なくとも光入射面近傍に複数の異なる屈折率層を有し、光射出面に近い部分に均一な屈折率分布を持つ層を有することを特徴とする照明装置。

【請求項４】　請求項１記載の集光部材は、光射出方向に対して後方部が光源の中心を焦点とする放物面で形成され、光射出方向に対して前方部が光源を中心とする円筒面で構成されていることを特徴とする照明装置。

【請求項５】　請求項１記載の集光部材の開口部は、上記導光部材の光入射面のうち、高屈折率部分に対向して配置されていることを特徴とする照明装置。

【請求項６】請求項１記載の導光部材は、中央の高屈折率層に対し、周辺部に光軸と平行に低屈折率層を配置したことを特徴とする照明装置。

【請求項７】　請求項１記載の導光部材は、光入射面近傍において、その光軸上に高屈折率部で正のパワー、低屈折率部で負のパワーとなるようなレンズ又はそれと等価な形状を連続的に形成したことを特徴とする照明装置。

【請求項８】　請求項１記載の導光部材は、ガラス又は透明樹脂によって構成されていることを特徴とする照明装置。

【請求項９】　請求項１記載の導光部材は、光入射面近傍において、高屈折率層を徐々に狭める低屈折率層を周辺部に設けたことを特徴とする照明装置。

【請求項１０】　請求項１記載の導光部材は、光入射面近傍において、屈折率分布型の光学材料からなり、かつ、この屈折率分布型の層の長さは結像系の長さのほぼ半分の長さとなっていることを特徴とする照明装置。

【請求項１１】　請求項２、３、６、７、９、１０のいずれかに記載の導光部材の各異屈折率層の境界面は、各層の屈折率に近い透明接着材によって接着固定されていることを特徴とする照明装置。

【請求項１２】　請求項１記載の導光部材は、光軸方向に異屈折率層を並設し、各層の少なくとも片面を曲面で構成したことを特徴とする照明装置。

【請求項１３】　閃光を発する閃光発光管と、該閃光発光管からの射出光束を集光させる反射傘と、該反射傘の開口部と同等、又はそれより広い光入射面を有し、光束を所定の射出位置まで導く導光部材とからなり、上記導光部材は少なくとも光入射面近傍において、複数の屈折率層から形成されることを特徴とする撮影用閃光発光装置。

【請求項１４】　略円筒形状の有効発光部を有する閃光発光管と、該閃光発光管からの射出光束を集光させる反射傘と、該反射傘に設けられた略矩形の開口部と同等又はそれより広い光入射面と光を被写体方向に照射させるための光射出面およびこの光入射面と光出射面間を結ぶほぼ一定厚みの平滑面からなる導光部材とからなり、上記導光部材は、少なくとも光入射面近傍において、複数の屈折率層から形成されることを特徴とする撮影用閃光発光装置。

【請求項１５】　請求項１３又は１４記載の導光部材は、中心部に高屈折率部、外周部に低屈折率を配列したことを特徴とする撮影用閃光発光装置。

【請求項１６】　請求項１３又は１４記載の導光部材は、少なくとも光入射面近傍に複数の異なる屈折率層を有し、射出面に近い部分に均一な屈折率分布を持つ層を有することを特徴とする撮影用閃光発光装置。

【請求項１７】　請求項１３又は１４記載の集光部材は、光射出方向に対して後方部が光源の中心を焦点とする放物面で形成され、光射出方向に対して前方部が光源を中心とする円筒面で構成されていることを特徴とする撮影用閃光発光装置。

【請求項１８】　請求項１３又は１４記載の反射傘の開口部は、上記導光部材の光入射面のうち、高屈折率部分に対向して配置されていることを特徴とする撮影用閃光発光装置。

【請求項１９】　請求項１３又は１４記載の導光部材は、中央の高屈折率層に対し、周辺部に光軸と平行に低屈折率層を配置したことを特徴とする撮影用閃光発光装置。

【請求項２０】　請求項１３又は１４記載の導光部材は、光入射面近傍において、その光軸上に高屈折率部で正のパワー、低屈折率部で負のパワーとなるようなレンズ又はそれと等価な形状を連続的に形成したことを特徴とする撮影用閃光発光装置。

【請求項２１】　請求項１３又は１４記載の導光部材は、ガラス又は透明樹脂によって構成されていることを特徴とする撮影用閃光発光装置。

【請求項２２】　請求項１３又は１４記載の導光部材は、光入射面近傍において、高屈折率層を徐々に狭める低屈折率層を周辺部に設けたことを特徴とする撮影用閃光発光装置。

【請求項２３】　請求項１３又は１４記載の導光部材は、光入射面近傍において、屈折率分布型の光学材料からなり、かつ、この屈折率分布型の層の長さは結像系の長さのほぼ半分の長さとなっていることを特徴とする撮影用閃光発光装置。

【請求項２４】請求項２、３、６、７、９、１０のいずれかに記載の導光部材の各異屈折率層の境界面は、各層

の屈折率に近い透明接着材によって接着固定されていることを特徴とする撮影用閃光発光装置。

【請求項２５】　請求項１３又は１４記載の導光部材は、光軸方向に異屈折率層を並設し、各層の少なくとも片面を教区面で構成したことを特徴とする撮影用閃光発光装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は光源からの射出光を効率よく制御する照明装置および撮影用閃光発光装置に関するものである。

【０００２】

【従来の技術】従来、光源からの光を複数回反射させる光路を介して被写体に照射させる照明装置としては、特開平４－１６８３３号公報に示されるように、近距離の被写体に対し拡散光を得ることを目的とし、光源から射出された光束をその前面に略平行に配置された複数の平面鏡で複数回反射させて拡散させた後、被写体に照射させるものが提案されている。

【０００３】また、本出願人が特開昭５９－１６５０３７号公報で提案したように、閃光発光管から射出した光束を帯状に集光させ、その集光部にファイバーを配置し、これを適宜束ねることによって所定の配光が得られるように構成したものがある。

【０００４】

【発明が解決しようとする課題】しかしながら、上記前者の従来例では、導光路として略平行に配置した拡散効果を有する平面鏡を用いているため、鏡面での反射の際に光損失が生じやすい。このため、接写等のように近距離の被写体を照明するのには、減光ができるため、都合が良いが、効率良く集光させるという目的に対しては不向きという課題があった。

【０００５】また、上記後者の従来例では、閃光発光管からの光束を反射傘で集光した位置にファイバーの入射部を配置して、光をファイバーの射出部に導くように構成しているが、ファイバーが円筒形状であり、隙間なく敷き詰めることができないため、光量ロスが生じる。又、ファイバーが極めて高価なこと、配光特性をファイバー内では制御できない（光入射時と光射出時で同様の集光状態）など課題があった。

【０００６】本発明は発光部としての光入射部と光射出部が離れた位置にある照明系であっても、導光路中での光の集光制御を該導光路の外形形状によらずに行わせることを目的とする。

【０００７】また、写真撮影用の照明として利用される閃光発光装置において、問題となる赤目現象を防止すると同時に光源からの光の集光制御を効率良く行うことを目的とする。

【０００８】さらに、写真撮影用の閃光発光装置の光源として利用される円筒形状の閃光発光管に対応した最適

な集光光学系を得る。すなわち、光源に対応した薄い導光部を介して光線を導き、光源の発光エネルギーを効率良く被写体に照射することを目的とする。

【０００９】

【課題を解決するための手段】この発明に係る照明装置は、光源からの光束を集光させる集光部材と、この集光部材によって集光された光束を所定の射出位置まで導く導光部材を有し、この導光部材は、光入射部において、光入射時の配光特性を調整する複数の屈折率層を備えることにより、上記導光部材の外形形状に依らない効率の良い集光制御が可能である。

【００１０】この発明に係る撮影用閃光発光装置は、閃光を発する閃光発光管と、該閃光発光管からの射出光束を集光させる反射傘と、該反射傘の開口部と同等又は、それより広い光入射面を有し、光束を所定の射出位置まで導く導光部材を有し、上記導光部材は光入射面近傍において、光入射時の配光特性を調整する複数の屈折率層を備えることにより、撮影装置の光源である閃光発光装置を使用する時、赤目現象を防止するため、発光部と光射出部を離すことが必要となるが、この間を結ぶ導光部材に屈折率勾配を設けることにより、光入射時の配光特性に対し、必要とされる配光特性に適宜補正することが可能となる。

【００１１】また、この発明に係る撮影用閃光発光装置は、略円筒形状の有効発光部を有する閃光発光管と、この閃光発光管からの射出光束を集光させる反射傘と、該反射傘に設けられた略矩形の開口部と、同等又はそれより広い光入射面と、光を被写体方向に照射させるための光射出面とおよびこの光入射面と光射出面間を結ぶほぼ一定厚みの反射面からなる導光部材を有し、この導光部材は、光入射部近傍において、光入射時の配光特性を調整する複数の屈折率層を備えることにより、薄型でコンパクトな発光部形態を実現でき、また集光特性も最適な状態に設定することが可能になる。

【００１２】

【発明の実施の形態】以下、この発明の実施の一形態を説明する。

【００１３】実施の形態例１

図１～図４はこの発明を写真撮影用カメラに適用した場合の構成を示す図であり、図１はカメラ全体の斜視図、図２は図１の要部の拡大透視図、図３は撮影状態を示す横断面図、図４は不撮影状態を示す横断面図である。

【００１４】図１において、１はカメラ本体、２は撮影レンズ鏡筒部、３は携帯時、図４に示すように撮影レンズ鏡筒部２を保護する鏡筒バリアであり、写真撮影時には図３に示すように、カメラ本体上部に設けたヒンジ部４を中心に回動して上方に退避し、所定位置に保持固定される。

【００１５】カメラ本体１の内部には図２に示すように、光源としての閃光発光管５及び該閃光発光管からの

光束を集光させる集光部材としての反射傘６とからなる閃光発光部が配置されている。また、鏡筒バリア３内には、カメラ本体１の内部に形成された閃光発光部からの射出光束を、所定の位置に導く導光部材７が配置されている。

【００１６】図３、４に示す断面図において、８は導光部材７を保持して鏡筒バリア３を形成する外装部材、９は導光部材７の外装部材８とは反対側の面を保持する保持部材であり、外装部材８に固定されている。尚、導光部材７は外装部材８、保持部材９と所定間隔離れた状態で保持され、外力による破損を防止すると共に、手や他の物の接触による光損失を防止している。

【００１７】１０はカメラ本体１に設けた上記閃光発光部の開閉部材であり、撮影状態では図３に示すように、鏡筒バリア３の動きに対応して、カメラ本体内の機構部材（不図示）により駆動されて閃光発光部の前面より待避する。一方、不撮影状態では図４に示すように閃光発光部の前面を覆い隠す位置に移動し、カメラ本体１の不使用時に閃光発光部周辺にゴミ、ホコリ等の侵入を防止する。

【００１８】また、図３は閃光発光管より射出する代表光束の光線追跡も示している。図示のように、閃光発光管から射出した光束は、導光部材７にその光入射面７ａから入射し、全反射を繰り返した後、光射出面７ｂより射出される。図示のように導光部材７は、外観形状に対応した形状に形成できるが、厚み変化がない状態での配光特性の制御は容易ではない。以下、この配光特性の制御について説明する。

【００１９】図５、図６は導光部材７内の屈折率変化により、集光性を変化させる過程を説明する図である。図５は円筒状の閃光発光管５に対して垂直方向に切断した場合の閃光発光部の断面図であり、図６は比較のために導光部材に屈折率変化部がない単一屈折率の材料を使用した場合の閃光発光部の断面図である。

【００２０】図５、図６において、閃光発光管５からの発光光束を集光させる反射傘６は、光射出方向に対して後方部が閃光発光管５の中心を焦点とする楕円面で形成され、光射出方向に対して前方部が閃光発光管５を中心とする円筒面で構成されている。

【００２１】１０は導光部材であるが、説明を容易にするため、前記図１～図４に示した導光部材７より短く、また、平板で構成している。この導光部材１０は３種の屈折率の異なる層１０Ａ～１０Ｃによって形成されており、１０Ａは光入射面から光射出面まで伸びる屈折率の高い層、１０Ｃは光入射面の最外周部に位置する屈折率の低い層、１０Ｂは上記両層１０Ａ、１０Ｃの中間の屈折率を有する層（以下、中屈折率層と称する）である。上記中屈折率層１０Ｂと低い層１０Ｃは光入射部に所定の長さのみ構成されている。

【００２２】一方、比較として図６に示した導光部材１１は、単一の屈折率層であり、図５との比較が容易となるように導光部材１０の高屈折率層１０Ａと同一の材料を用いている。なお、導光部材１０及び１１は、ガラス又は透明樹脂によって構成され、導光部材１０の各異屈折率層の境界面Ｔ１、Ｔ２は、各層１０Ａ・１０Ｂ、１０Ｂ・１０Ｃの屈折率に近い透明接着材によって接着固定されている。

【００２３】次に図５、図６について、光線追跡の状態を説明する。まず、図５において、楕円反射面６ａの第１の焦点位置に配置した閃光発光管５の中心から射出し後方に進んだ光束は、反射傘６の反射面６ａが楕円形状であるため、楕円の第２の焦点位置Ｆに集光する（説明を簡単にするため、閃光発光管５のガラス厚は十分に薄いものとして、その屈折の影響は無視した）。この第２の焦点位置Ｆの近傍に導光部材１０の入射面が配置されているので、この焦点位置Ｆに集光した反射光は、導光部材１０の中央部に位置する高屈折率部１０Ａに入射する。まず、入射面において屈折し、入射後の角度の小さい成分についてはそのまま高屈折率部１０ａを進み光射出面から射出する。この成分は、本来、画面のほぼ中央部を照射される成分であり、これ以上の集光制御をされない成分であり、入射時と同一の角度で射出する。また、図示のように導光部材１０に入射後屈折した成分で、入射した高屈折率層１０Ａから隣りの中屈折率層１０Ｂに当る成分でも、入射角が所定値以下の場合、高屈折率層１０Ａと中屈折率層１０Ｂの境界面Ｔ１で全反射し入射時と同一の角度で射出する。この入射角度による後の制御の分類は、隣接する異屈折率層の屈折率の比によって決定される。すなわち、入射後の照射角度の第一次の規制はこの屈折率比によって決定される。

【００２４】図示の例では、高屈折率層１０Ａのほぼ中央から入射する成分について説明したが、高屈折率層１０Ａの中央から外れた成分（閃光発光管５の中心より外れた位置から射出した成分又は直接光で発生する成分についても同様であり、所定角度以下の入射成分）は、上述の第一次の規制（高屈折率層１０Ａと中屈折率層１０Ｂの境界面Ｔ１）により、入射時と同一の角度成分で射出される。

【００２５】次に、入射時に所定角度以上の成分については、中屈折率層１０Ｂ又、更に入射角度の大きい成分については低屈折率層１０Ｃまで光が進み別制御となる。

【００２６】以下、この光線追跡について説明する。

【００２７】高屈折率層１０Ａと中屈折率層１０Ｂとの境界面Ｔ１で所定以上の入射角の場合には全反射せず屈折する。この時、屈折光は高屈折率層１０Ａからそれより低い屈折率層１０Ｂ、１０Ｃに入射するため、屈折後の光線は光軸方向に近い角度の成分に変換される。この屈折後の光線はそのまま中屈折率層１０Ｂの端面から射出、または中屈折率層１０Ｂと低屈折率層１０Ｃの境界

面Ｔ２で全反射した後、中屈折率層１０Ｂの端面から射出される。この一連の光路により、光線は光軸方向に曲げられ、必要画角内の成分に変換される。この場合も中屈折率層１０Ｂと低屈折率層１０Ｃの屈折率の比を適宜調整することによって制御される角度成分が限定される。

【００２８】次に中屈折率層１０Ｂと低屈折率層１０Ｃの境界で全反射しえない、つまり初期状態で導光部材１０への入射角の大きい成分については、さらに中屈折率層１０Ｂから低屈折率層１０Ｃへ屈折して入射し、そのまま又は空気層との境界面Ｔ３で全反射した後、この低屈折率層１０Ｃの端面から射出する。この場合も上記高屈折率層１０Ａから中屈折率層１０Ｂへ入射した時と同様屈折後の光束は光軸の方向に曲げられ、必要画角内の成分に変換される。

【００２９】以上、説明したように、導光部材１０の入射光部近傍の中央部に高屈折率層１０Ａ、周辺に低屈折率層１０Ｂ、１０Ｃを配置し、低屈折率層１０Ｂ、１０Ｃを入射光の特性に応じて所定の長さに設定することにより、たとえ入射時の光線の方向にばらつきあっても、導光部材射出後は、方向の揃った光束、すなわち、任意の必要画角範囲に対応した照射を行うことができる。

【００３０】なお、この中低屈折率層１０Ｂ、１０Ｃの長さ及び層の厚さは、一度、中、低屈折率層１０Ｂ、１０Ｃに入射した光束が、全反射により再度現在の屈折率層より高い屈折率層に再入射するのを防止できる形状となっている。このため、入射光の角度のばらつき具合、また、入射位置のばらつき等によって最適値は異なる。

【００３１】また、導光部材射出後の照射範囲は、上述したように各屈折率層１０Ａ～１０Ｃの比によって制御される。さらに、最初に入射する高屈折率層１０Ａの値によって、中、低屈折率層１０Ｂ、１０Ｃの長さが規制される。

【００３２】上述の実施の形態例１では、屈折率層として、高、中、低の３種の屈折率層１０Ａ～１０Ｃを設定しているが、必ずしもこの３層に限定されるわけではなく、より細かく屈折率を区分することにより、より細かな配光制御を実現でき、ムラのない均一な照明とすることができる。

【００３３】また、上記の形態例１の効果を検証するため、図５及び図６は同一条件で光線トレースを行っている。まず、図６に示すように導光部材１１として単一の屈折率の材料を使用した場合、導光部材１１に入射する前と後は同一成分として射出する。（図中、入射時の最大の角度成分を射出面で２点鎖線で示し、より明確に示した）
これに対し、上記の実施の形態例１の場合は図５に示すように、入射時の最大の角度（２点鎖線）に対し、極めて狭い角度の光線の集まりとして集光しているのがわかる。図中の代表光線は閃光発光管５の中心部分から出た光線が後方の反射面で反射し、一点に集光した状態での光束を示しているが、実際には閃光発光管５の大きさが有限であり、また閃光発光管５のガラス管の面での屈折の影響があり、必ずしも、この光束だけには限らず、高屈折率部１０Ａの広い面から色々の角度成分の光が入射する。この場合にも上述の説明と同様の光線の制御により大多数の光束が、正常に規制される。すなわち、導光部材１０の入射角の大きい成分は光軸方向に近い角度成分に変換される。

【００３４】以下、上記説明の内容に基づく導光部材の構成の望ましいの例を、実際の数値をあてはめて図７を用いて説明する。

【００３５】図７において、１２は導光部材であり、高屈折率 n_H の材料１２Ａに中屈折率 n_M の材料１２Ｂ、低屈折率 n_L の材料１２Ｃを光入射側の端面の両側に貼り合わせた形で構成されている。

【００３６】まず、形状決定に当って各定数を以下のように定める。閃光発光管５から発光し反射傘６で集光された光束は、ある一定の狭い範囲で導光部材１２に入射する。この入射部の間口を点Ｐ、点Ｑ間の幅ａから入射すると仮定する。中屈折率層１２Ｂの幅をｂ、低屈折率層１２Ｃの幅をｃとし、導光部材１２全体の幅をｄ、中、低屈折率層１２Ｂ、１２Ｃの長さを

【００３７】

【外１】

1　又は（ℓ）

とする。また中屈折率層１２Ｂの端面と反対側の交点をＲ、Ｓ、導光部材射出後の光束の最大角度の目標値をαとする。

【００３８】基本的に入射光のうち、入射角がα以下の角度の成分については、高屈折率層１２Ａ内でのみ制御され、入射角度と同一角度で射出面から射出する。この時、中屈折率層１２Ｂに当った場合でも全反射し、中屈折率層１２Ｂに侵入しないように該中屈折率層の屈折率 n_M を設定している。

【００３９】また、入射光のうち、入射角がα以上β以下の角度の成分については、高屈折率層１２Ａから中屈折率１２Ｂには入射するが、中屈折率層１２Ｂと低屈折率層１２Ｃとの境界Ｔ２では全反射する成分である。同様に、入射光のうち、入射角がβ以上、γ以下の角度の成分は、高屈折率層１２Ａから、中屈折率層１２Ｂ、低屈折率層１２Ｃのすべてに入射しうる成分であり、低屈折率層１２Ｃと空気との境界面Ｔ３で全反射する成分である。

【００４０】上記条件に加え、中、低屈折率層１２Ｂ、１２Ｃで制御する光束をこの層にすべて侵入させるための該中、低屈折率層の長さ１の条件、また、中、低屈折率層１２Ｂ、１２Ｃの端面から射出する光束が、導光部材射出後、所定の角度α以内に収まるようにする条件、さらに一度、中、低屈折率層１２Ｂ、１２Ｃに入射した

光束が、より高い屈折率の層に戻らないための中、低屈折率層１２Ｂ、１２Ｃの厚みの条件等、各種条件を満たすことによってより効率良く集光させることが可能である。

【００４１】以下に各条件式を示す。

【００４２】・入射面での関係式

$$\sin\alpha = n_H \cdot \sin\theta_\alpha \qquad (1-1)$$

$$\sin\beta = n_H \cdot \sin\theta_\beta \qquad (1-2)$$

$$\sin\gamma = n_H \cdot \sin\theta_\gamma \qquad (1-3)$$

・中、低屈折率層１２Ｂ、１２Ｃの入射成分が直接抜けないための条件（ｌの長さ）。

【００４３】

【数１】

$$\ell \geqq a \cdot \tan(90^\circ - \theta_\alpha) \qquad (2-1)$$

$$\therefore \quad \ell \geqq \frac{a}{\tan\theta_\alpha} \qquad (2-2)$$

・屈折率変化境界面での条件式

$$n_H \cdot \sin(90^\circ - \theta_\beta) = n_M \cdot \sin\phi_\beta \qquad (3-1)$$

$$n_H \cdot \sin(90^\circ - \theta_\gamma) = n_M \cdot \sin\phi_\gamma \qquad (3-2)$$

$$n_M \cdot \sin\phi_\gamma = n_L \cdot \sin\psi_\gamma \qquad (3-3)$$

・中、低屈折率層１２Ｂ、１２Ｃの端面から、高屈折率層１２Ａに再入光する際、射出光の最大値が目標値以下とするための条件（最終射出光としてα以下とする条件）。

【００４４】

$$n_M \cdot \sin(90^\circ - \phi_\beta) \leqq n_H \cdot \sin\theta_\alpha \qquad (4-1)$$

$$n_L \cdot \sin(90^\circ - \psi_\gamma) \leqq n_H \cdot \sin\theta_\alpha \qquad (4-2)$$

・中、低屈折率層１２Ｂ、１２Ｃに入射し、全反射後、高屈折率層１２Ａに再入光しないための条件

【００４５】

【数２】

$$b \cdot \tan\phi_\beta \geqq \frac{\ell}{2} \qquad (5-1)$$

$$c \cdot \tan\phi_\gamma \geqq \frac{\ell - b \cdot \tan\phi_\gamma}{2} \qquad (5-2)$$

・中、低屈折率層１２Ｂ、１２Ｃの端面から完全に制御されていない成分が抜け出るのを防止するための条件

【００４６】

【数３】

$$a \cdot \tan(90^\circ - \theta_\beta) \leqq \frac{\ell}{2} \qquad (6-1)$$

$$c \cdot \tan\phi_\gamma \leqq \ell - \frac{a}{\tan\theta_\gamma} - b \cdot \tan\phi_\gamma \qquad (6-2)$$

以上のすべての条件を満たすことが望ましいが、実際には厚く大型化してしまうため、上記いくつかの条件を満たす形で実際の計算例を示す。

（数値計算例１）入射光開口幅ａ、高屈折率部１２Ａの屈折率n_H、射出後の最大照射角αをそれぞれ

$a = 2.0 \qquad n_H = 1.60 \qquad \alpha = 30^\circ$

として初期値として与える。

【００４７】また、条件として、中、低屈折率層１２Ｂ、１２Ｃの長さｌを最短とするために前記（２－２）式より

【００４８】

【数４】

$$\ell = \frac{a}{\tan\theta_\alpha} \qquad (7-1)$$

また、条件として、制御しうる最大の角γを大きくとる（端面からの射出を最大値θ_αと一致）ために、前記（４－１）より

$$n_M \cdot \sin(90^\circ - \phi_\beta) = n_H \cdot \sin\theta_\alpha \qquad (8-1)$$

$$n_L \cdot \sin(90^\circ - \psi_\gamma) = n_H \cdot \sin\theta_\alpha \qquad (8-2)$$

さらに、条件として、中、低屈折率層入射後は、高屈折率層に再入光せず、最も薄くするために（５－１）式より、

【００４９】

【数５】

$$b \cdot \tan\phi_\beta = \frac{\ell}{2} \qquad (9-1)$$

（５−２）式より、

【００５０】

【数６】

$$c \cdot \tan\phi_\gamma = \frac{\ell - b \cdot \tan\phi_\gamma}{2} \qquad (9-2)$$

前記（３−１）～（３−３）の条件式で所定角で全反射する条件、すなわち入射角αで高屈折率層１２Ａと中屈折率層１２Ｂとの境界Ｔ１で全反射、射出角βで中屈折率層１２Ｂと低屈折率層１２Ｃとの境界Ｔ２で全反射する条件は、ϕ_β＝０、ψ_γ＝０となり、次式となる

$$n_M = n_H \cdot \sin(90° - \theta_\alpha) \qquad (10-1)$$

$$n_L = n_H \cdot \sin(90° - \theta_\beta) \qquad (10-2)$$

以上の関係から、以下の順序で各定数を求める。（１−１）式と（７−１）式より

【００５１】

【数７】

$$\ell = \frac{a}{\tan\left[\sin^{-1}\left(\frac{\sin\alpha}{n_H}\right)\right]} \qquad (11)$$

（１０−１）式と（１−１）式より

$$n_M = n_H \cdot \cos\left[\sin^{-1}\frac{\sin\alpha}{n_H}\right] \qquad (12)$$

（１−１）式と（８−１）式より

$$\phi_\beta = \cos^{-1}\frac{\sin\alpha}{n_M} \qquad (13-1)$$

$$\beta = \sin^{-1}\left[n_H \cdot \sin\left(\cos^{-1}\left(\frac{n_M}{n_H} \cdot \sin\phi_\beta\right)\right)\right] \qquad (13-2)$$

（９−１）式より

$$b = \frac{\ell}{2\tan\phi_\beta} \qquad (14)$$

（３−１）式と（１−１）式と（８−１）式より

$$\theta_\beta = \cos^{-1}\left[\frac{n_M}{n_H} \cdot \sin\left(\cos^{-1}\left(\frac{\sin\alpha}{n_M}\right)\right)\right] \qquad (15)$$

【００５２】

【数８】

（１０－２）式より

$$n_L = n_H \cdot \sin(90° - \theta_\beta) \qquad (16)$$

（８－２）式と（１－１）式より

$$\phi_\gamma = \cos^{-1}\left(\frac{\sin\alpha}{n_L}\right) \qquad (17-1)$$

（３－３）式と（１－３）式より

$$\gamma = \sin^{-1}\left[n_H \cdot \sin\left(\cos^{-1}\left(\frac{n_L}{n_H}\cdot \sin\phi_\gamma\right)\right)\right] \qquad (17-2)$$

（９－２）式と（３－３）式より

$$C = \frac{\ell - b\cdot \tan\left[\sin^{-1}\left(\frac{n_L}{n_H}\cdot \sin\phi_\gamma\right)\right]}{2\cdot \tan\phi_\gamma} \qquad (18)$$

一方、図７より、

$$d = a + 2b + 2c \qquad (19)$$

以上より計算結果は、

α＝３０．０°，　β＝４５．０°，　γ＝５９．９°，　ａ＝２．０

ｂ＝１．０６　，　ｃ＝０．７５　，　ｄ＝５．６２　，　ｌ＝６．０８

n_H＝１．６０００，n_M＝１．５１９９，n_L＝１．４３５３

となる。図７はこの数値を元にして画いた図である。

【００５３】また、高屈折率部１２Ａの屈折率のみをn_H＝１．５に変更して同様の計算をすると、次のような数値計算例２となる。すなわち、

α＝３０．０°，　β＝４５．０°，　γ＝６０．０°，　ａ＝２．０

ｂ＝１．０７　，　ｃ＝０．７６　，　ｄ＝５．６９　，　ｌ＝５．６６

n_H＝１．５０００，n_M＝１．４１４２，n_L＝１．３２２９

となり、中、低屈折率層１２Ｂ、１２Ｃの長さが０．４ｍｍ短く他はほぼ同様の値となる。

【００５４】上記数値の形態例では、導光部材射出後の最大角度３０°として均一配光となり、かつ損失が少ないように各定数を設定している。このため、幅が厚くな＊っているが、導光部材１２の射出光の分布を中央重点の分布とし、ある程度損失光を許容することができればより薄く構成することができる。

【００５５】また、上記説明のように、屈折率の異なる層を光軸に対し平行に配置し、かつ入射光部の屈折率を高く、周辺に向うに従って屈折率を下げることによって、入射時の角度成分によって分類し、各々別々に光線方向を制御することが可能となる。この時、異なる屈折率層を多数配置することにより、光をより細かく制御でき、最終的な導光部材射出後の角度を狭くできると共に、入射時の角度に関しても広い角度の成分まで制御可能となる。

【００５６】次に、上記の実施の形態例１の数値計算例３を説明する。前記数値計算例１では、中、低屈折率層の長さを最短とするための条件を（７－１）式で与えたが、数値計算例３では、数値計算例１でわずかに生じる中、低屈折率層の端面から、完全に制御されない状態で抜け出る成分をなくす形状について説明する。

【００５７】この条件を満たし中、低屈折率部の長さを短くするには（６－１），（６－２）式より

【００５８】

【数９】

$$a\cdot \tan(90° - \theta_\beta) = \frac{\ell}{2} \qquad (20-1)$$

$$c\cdot \tan\phi_\gamma = \ell - \frac{a}{\tan\theta_\gamma} - b\cdot \tan\phi_\gamma \qquad (20-2)$$

この条件に加え、制御し得る拡大の角度γを大きくとるための条件（８－１），（８－２）式、中、低屈折率層入射後、高屈折率層に再入射しない条件（９－１），（９－２）式、所定角度で全反射する条件（１０－１），（１０－２）式また、各屈折面での定義式（１－１）～（１－３），（３－１）～（３－３）式より所定値を計算する。

【００５９】入射光開口幅ａ、高屈折率部１３Ａの屈折

率n_H、射出後の照射角αをそれぞれ

a＝2．0、　n_H＝1．60，　α＝30°

として、数値計算例1と同一の値を与え、図8に示すよ＊うに低屈折率層13Bを1層とすると、

【0060】

【数10】

（1－1）式と（10－1）式より

$$n_L = n_H \cdot \sin\left(90^\circ - \sin^{-1}\frac{\sin\alpha}{n_H}\right) = 1.5199$$

（8－1），（1－1）式より

$$\phi_\beta = \cos^{-1}\frac{\sin\alpha}{n_L} = 70.7934$$

（3－1）式より

$$\phi_\beta = \cos^{-1}\frac{n_L}{n_H}\sin\phi_\beta = 26.2254$$

（20－1）式より

$$\ell = 2a \cdot \tan(90^\circ - \theta_\beta) = 8.12$$

（9－1）式より

$$b = \frac{\ell}{2 \cdot \tan\phi_\beta} = 1.4144$$

（1－2）式より

$\beta = \sin^{-1}(n_H \cdot \sin\theta_\beta) = 44.9951$

$d = a + 2b = 4.8288$

以上の結果をまとめると、

α＝30．0°，　β＝45．0°，　a＝2．0，

b＝1．41

d＝4．83，l＝8．12，　n_H＝1．6000，

n_M＝1．5199

となり、上記構成により所定範囲a内の90°の照射角の成分を60°の照射角に狭められる。

【0061】上記各構成は、光量ロスを極力防止する構成を示したが、必ずしもこの形状に限定されることなく、光軸方向に対し略平行となるように屈折率の異なる層を形成し、かつ、入射部を高屈折率部、光軸から離れるにつれて屈折率を下げるように構成することによって、たとえ十分な厚みをとれない場合でも同様の効果が得られる。

【0062】実施の形態例2

図9～図12は導光部材内の屈折率変化により、集光性を変化させる過程の実施の形態例2を説明する図であり、全体の構成等は実施の形態例1と同様であるため、特徴的な部分のみの説明を行う。

【0063】図9において、14は導光部材であり、屈折率の異なる4つの層14A、14B、14C、14Dから構成され、外形形状としては、平板状になっている。ここで14A、14Cは高屈折率層、14B、14Dは低屈折率層である。本実施の形態例2は実施の形態例1とは異なり、光軸方向に異屈折率材料を並設し、その接合面が曲面となっていることが特徴である。このように構成することによって、入射光面に複数の凸レンズを配置したような効果が得られる。

【0064】以下、このような形状の導光部材14を利用した場合の光線追跡を図10～図12について説明する。説明を簡単にするため、閃光発光管5の中央から射出した光線について示す。

【0065】まず、図10に示すように、楕円反射傘6の第1の焦点位置に配置した閃光発光管5から射出した光束のうち、光軸の後方に向う光束は反射傘6の楕円面6aに当った後、楕円の第2の焦点位置Fに集光する（説明を簡単にするため、閃光発光管のガラス管の影響を無視する）。この第2の焦点位置Fの近傍に集光部材14の高屈折率部14Aが配置されているので、第2の焦点位置Fに焦光した反射光は高屈折率部14Aに入射し屈折する。次に、高屈折率部14Aと低屈折率部14Bの境界面T1に入射する。この境界面は曲面で構成されているため、入射角が小さく屈折の影響を受けにくい。

【0066】さらに、低屈折率層14Bから高屈折率層14Cに進んで屈折する。最後は高屈折率層14Cから低屈折率層14Dに入射する。この時も境界面T2が曲面で構成されるため、入射角が小さく、屈折による角度の振れを抑えることができる。

【0067】以上のように、導光部材14の入射面近傍に高屈折率層14A、低屈折率層14Bを順に配置し、かつ、高屈折率層14Aを凸レンズ形状、低屈折率層14Bを凹レンズ形状となるように構成することにより、集光効果を持たせることができる。

【0068】図11は閃光発光管5の中央から射出した

光束が直接、導光部材１４に入射する場合の状態を示している。図示のように、高屈折率層１４Ａ、１４Ｃがあたかも凸レンズの効果を有し、導光部材１４から射出後、一点に集光するような特性を得ることができる。

【００６９】図１２は閃光発光管５から出た光束が円筒状の反射面６ｂに当る成分を図示したものである。この光束は円筒状の反射面６ｂで反射後、再度閃光発光管５の中心を通って後方に向い楕円反射面６ａで反射後、第２の焦点位置Ｆに集光する。以下は図１０と同一の光路をとる。

【００７０】以上、説明したように、高屈折率部１４Ａ、１４Ｃは中央が厚く周辺を薄くし、低屈折率部１４Ｂ、１４Ｄは中央が薄く周辺が厚い層を導光部材の入射面近傍に光軸方向に積層させることにより、外形形状は一定に保ちながら、集光特性を変化させせることができる。

【００７１】本実施の形態例２では、高、低各屈折率層を各２層ずつ計４層形成したが、この層の数を増やすことも可能であり、また、２層だけで構成することも可能である。いずれも、高、低の屈折率の差及び曲率の大きさによって集光度合を可変させせることができる。

【００７２】また、本実施の形態例２では、片面を平面としているが必ずしもこの形状に限定されることなく、鏡界面をすべて凸面、又は凹面で形成することもでき、この方が効率よく集光できる。また屈折率差も大きい方が効率良く集光させせることができる。

【００７３】実施の形態例３

図１３～図１５は本発明の実施の形態例３を説明するための図である。全体の構成等は実施の形態例１と同様であり、特徴的な部分についてのみ説明を加える。

【００７４】図１３において、１５は導光部材であり、１５Ａは高屈折率部、１５Ｂは断面形状が３角形とした低屈折率部である。本実施の特徴は実施の形態例１、２の中間の特性を持つ構成であり、図１４、１５に示す光線追跡図をもとに形状の特性を説明する。まず図１４に示すように閃光発光管５の中心から出た光束のうち後方の反射傘で反射した成分は楕円のもう一方の焦点Ｆに集光し、導光部材１５に入射する。光軸近傍の光束は実施の形態例１同様、高屈折率部１５Ａに入射しそのまま射出する一方周辺に向った成分については実施の形態例２で説明したように低屈折率部１５Ｂの３角形の部分が凹レンズに相当する効果を持ち、ここの部分で特に入射角の大きい成分のみが制御され集光する。

【００７５】図１５は閃光発光管５からの直接光であるが、この場合も上記低屈折率部１５Ｂで形成された３角形の部分で効果的に集光され導光部材の端面から射出されていることがわかる。

【００７６】実施の形態例４

図１６は本発明の実施の形態例４を説明するための図である。全体の構成等は実施の形態例１と同様であるか

ら、特徴的な部分についてのみ説明する。

【００７７】図１６において、１６は導光部材であり、１６Ａは屈折率分布型の光学材料であり、中心部の屈折率が高く周辺部が低い屈折率を有し屈折率の変化が放物線状に変化を持たせた材質である。その長さは後述するように所定の長さに規制されている。１６Ｂは屈折率分布層１６Ａの光軸端面に接続された単一の屈折率よりなる導光部であり、この長さは使用する光学系の長さに応じて任意の長さにすることが可能である。

【００７８】同図では、この光学系を利用した場合の理想的な光線トレースも同時に示している。

【００７９】閃光発光管５の中央から射出した光束のうち後方に向う成分は楕円のもう一方の焦点位置に集光する。この集光近傍に入射面を配置した導光部材１６の導光部材の光軸中心付近に入射した光束は、屈折率分布層１６Ａにおいて、この層の長さを所定の長さに設定することにより、略平行化することができる。平行化された後は、単一の屈折率層１６Ｂに入射し、この光線状態を保持したまま、所定位置まで光束を導く。

【００８０】この方式は光源からの光束が反射傘等によって十分に光軸上に集光されている状態、又は、それと等価となるように光源に対し、導光部材の入射面が広い場合に特に有効である。

【００８１】また屈折率分布層１６Ａの長さは、通常セルホック（商品名）レンズ、ロッドレンズ等で使われている屈折率分布型のレンズの結像関係時に使用する長さのちょうど半分になっていることが特徴的である。

【００８２】また、この長さについては、上記長さに限定されることなく、導光部材に入射する光線の特性に応じ最適な長さにすることが望ましい。

【００８３】

【発明の効果】以上説明したように、本発明によれば、導光部材の光入射部を複数の屈折率層で形成したので、導光部材の外形形状によらず、任意の集光特性の制御が可能となり、効率の良い照明光学系を実現できる効果がある。

【００８４】また、導光部材の長さを任意の長さとすることが可能なため、光射出部を撮影光軸から離すことが可能であり、閃光発光装置を利用した撮影時問題となる赤目現象を未然に防止することができる。

【００８５】さらに、導光部材は、光入射部近傍において、複数の屈折率層を形成しているので、薄型でコンパクトな発光部形態を実現でき、集光特性も最適状態に設定することが可能である。しかも、光学系の構成も比較的簡単であり、安価に構成できるなどの効果がある。

【図面の簡単な説明】

【図１】本発明の実施の形態例１に係るカメラ全体の斜視図。

【図２】本発明の実施の形態例１に係る光学系のみを透視して示した斜視図。

【図３】本発明の実施の形態例１に係るカメラ使用状態の断面図。

【図４】本発明の実施の形態例１に係るカメラ携帯時の断面図。

【図５】本発明の実施の形態例１に係る照明光学系を説明するための断面図。

【図６】本発明の実施の形態例１に係る照明光学系を説明するための比較の断面図。

【図７】本発明の実施の形態例１に係る導光部材の特性を説明するための断面図。

【図８】本発明の実施の形態例１に係る導光部材の特性を説明するための他の断面図。

【図９】本発明の実施の形態例２に係る照明光学系を説明するための断面図。

【図１０】本発明の実施の形態例２に係る照明光学系の後面反射光線トレース図。

【図１１】本発明の実施の形態例２に係る照明光学系の直接光線トレース図。

【図１２】本発明の実施の形態例２に係る照明光学系の前面反射光線トレース図。

【図１３】本発明の実施の形態例３に係る照明光学系を説明するための断面図。

【図１４】本発明の実施の形態例３に係る照明光学系の後面反射光線トレース図。

【図１５】本発明の実施の形態例３に係る照明光学系の植設光線トレース図。

【図１６】本発明の実施の形態例４に係る照明光学系を説明するための断面図。

【符号の説明】

５　閃光発光管（光源）

６　反射傘（集光部材）

７、１０、１１、１２、１３、１４、１５、１６　導光部材

７ａ　光入射面

７ｂ　光射出面

８　外装部材

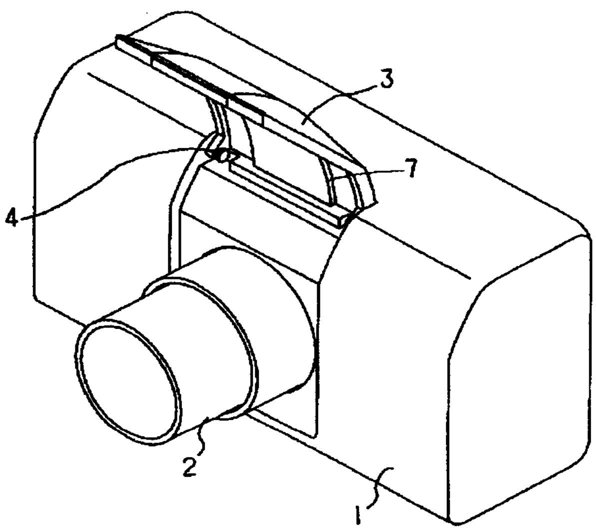
９　保護部材

１０Ａ、１２Ａ、１４Ａ、１４Ｃ、１５Ａ　高屈折率層

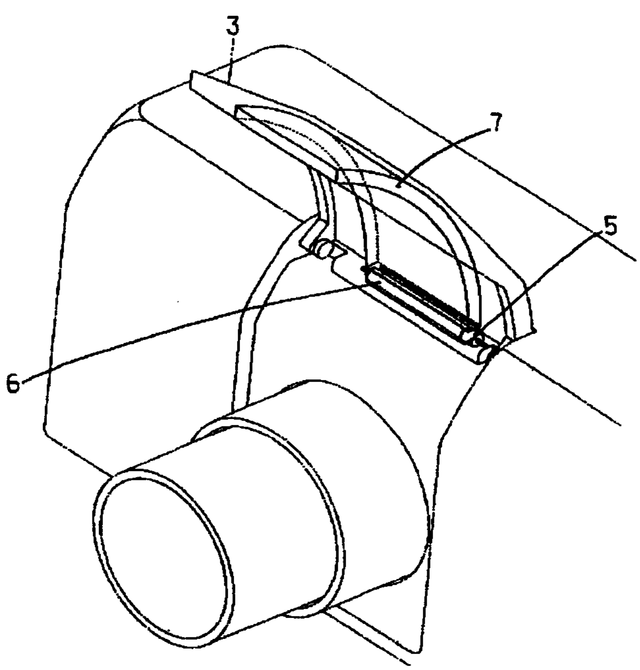
１０Ｂ、１２Ｂ　中屈折率層

１０Ｃ、１２Ｃ、１４Ｂ、１４Ｄ、１５Ｂ　低屈折率層

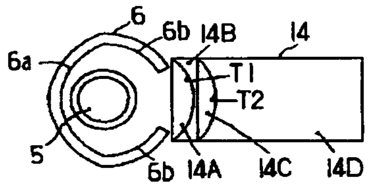
【図１】



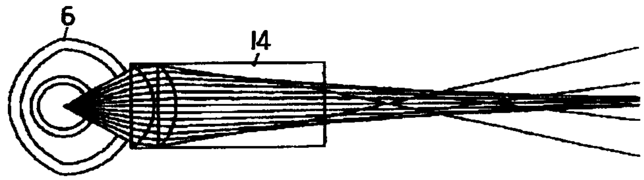
【図２】



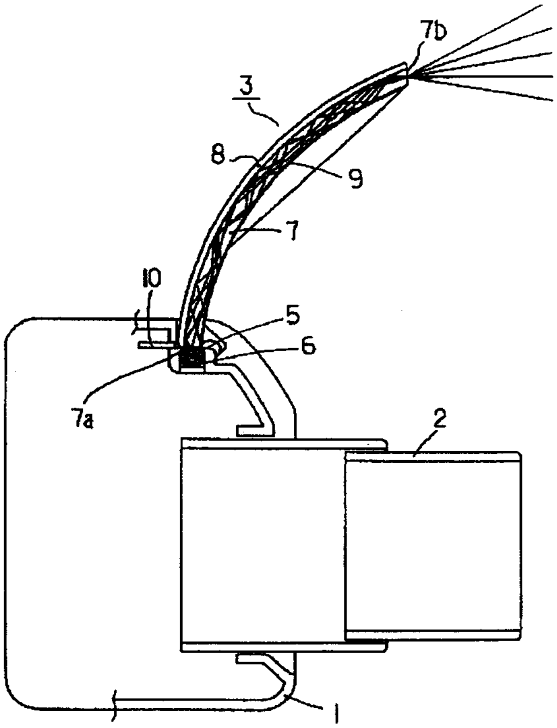
【図９】



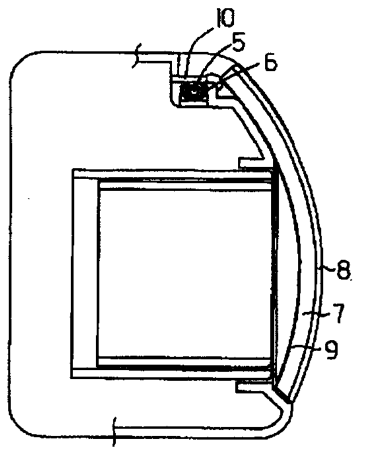
【図１１】



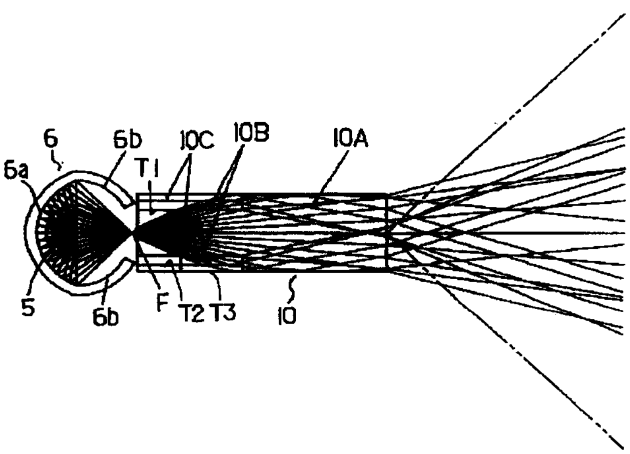
【図３】



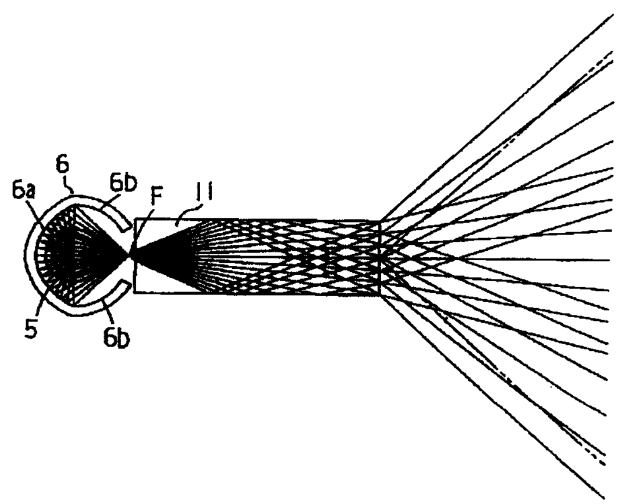
【図４】



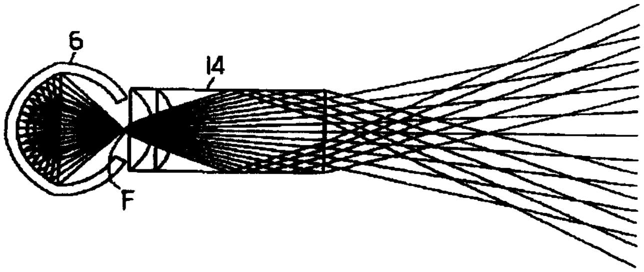
【図５】



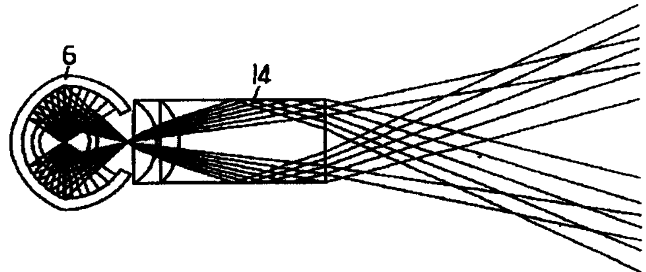
【図６】



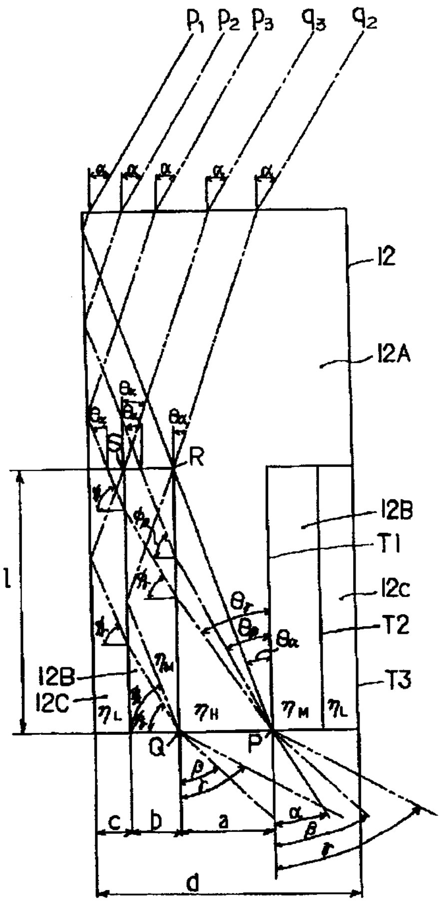
【図１０】



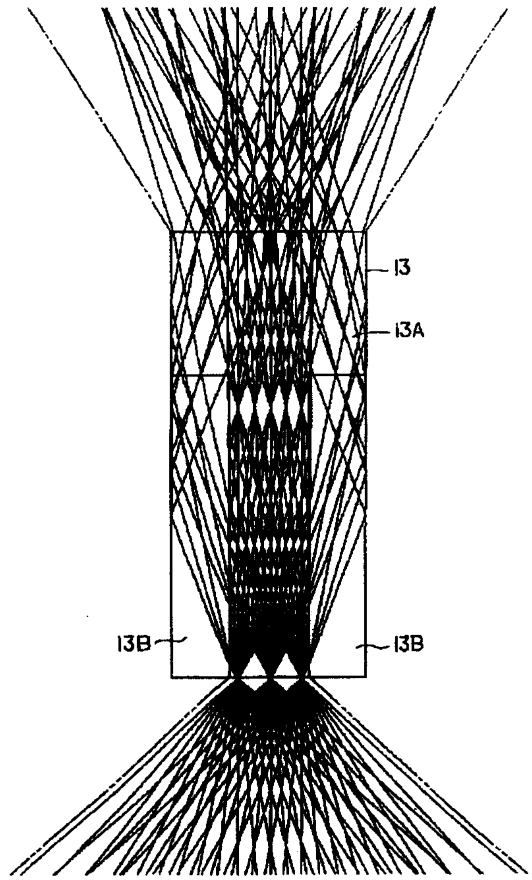
【図１２】



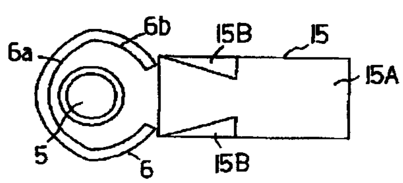
【図７】



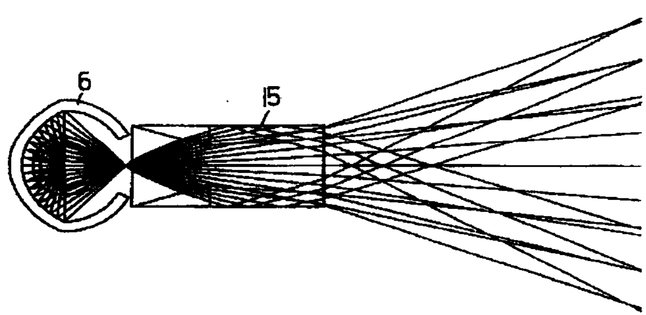
【図８】



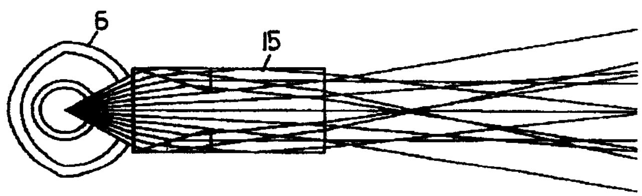
【図１３】



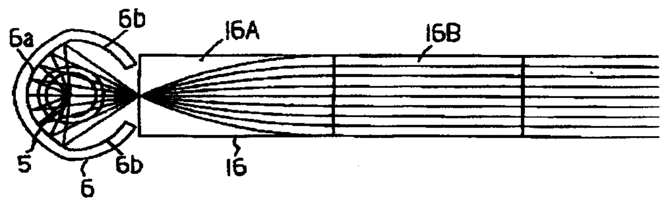
【図１４】



【図１５】



【図１６】



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【補正対象項目名】図４
【補正方法】変更
【補正内容】
【図４】